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# THE CLEANING *and* ELECTRO-PLATING *of* METALS

A manual of information and instruction written for the benefit of the Electro-Plater and those interested in the art of Electro-Plating

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*Printed by the*
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*for*
*Members of the American Electro-Platers Society and The Plating Trade*



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## PREFACE.

This book has been written to offer in a non-technical manner, the best methods of current practice, in the electro-plating of metals. Enough supplementary text, on the preparing of metals for plating and the analysis of solutions has been added, to make the information coherent and complete.

In compiling this book, I have endeavored to make it practical in every detail, wording it in concise and simple language and avoiding technical terms as much as possible.

I trust it will prove of benefit to my fellow members of the American Electro-Platers' Society, and to platers in general.

HERMAN H. REAMA.

Brooklyn, N. Y., 1917.

## THE BASIS OF ELECTRICAL RULES.

IN order that the operator of an electro-plating plant may intelligently handle the currents used for the plating baths, and turn out work efficiently, it is essential that at least the fundamental principles of electricity should be understood.

The cause of a manifestation of any kind of energy is force. Electric energy in the form of a current is caused by a difference of electric potential, or electromotive force (e.m.f.). The unit by which this force or pressure, which causes an electric current to flow, is measured, is called a *volt*. The current which flows is measured in *amperes*. The unit of resistance to the flow of current in a conductor is the *ohm*.

One volt is about the value of the potential of a Daniell's Cell; it is the electromotive force which will force a current of one ampere thru a resistance of one ohm. One ampere is the current which will plate out **0.01973** grams of copper per minute from a copper sulphate bath. This measures not only the current intensity, or available working energy, but also the rapidity of its work: — a current of **10** amperes can do in **1** second, what a current of **1** ampere requires **10** seconds to do. One ohm is the resistance at **0°** C. of a column of mercury **1** meter long and **1** sq. m.m. in cross section. The *coulomb* is the unit of quantity of electricity and is the amount of electricity carried by a current of one ampere in one second.

Ohm's law expresses the relationship in an electric circuit, of the voltage, current and resistance, as follows:

The voltage is always equal to the product of the current and the resistance — Volts = Amperes X Ohms. If 6 volts are impressed on a circuit of 2 ohms resistance, 3 amperes will flow.

This law may be expressed in two other forms:

$$\text{Amperes} = \frac{\text{volts}}{\text{ohms}}$$

$$\text{Ohms} = \frac{\text{volts}}{\text{amperes}}$$

From these equations it is evident that the current varies directly with the voltage and inversely with the resistance, — if the voltage be doubled, twice the current will flow, etc.; if the resistance be doubled, half the current will flow.

The resistance varies directly with the voltage and inversely with the current.

The voltage varies directly with the current and directly with the resistance.

This law is the fundamental principle in most electric calculations.

E is generally symbolic of voltage, C of current, R of resistance.

$$E = C \times R.$$

## CLEANING THE WORK.
### The Use of O. P. C.

The term cleanliness, when applied to metal surfaces which are to be plated, means *absolute* freedom from the least trace of dust, grease, oil, rust, corrosion, tarnish, or any form whatever of foreign matter. A surface made clean by any mechanical means alone, will not serve for electro-plating because of loose metal dust, and particles of polishing material or lubricant left on the work. A perfectly clean surface once touched with the hand is no longer clean and will peel or strip where touched. Articles to be plated usually have their surfaces prepared first by mechanical means — as buffing — and are then made chemically clean by suitable solutions. Each metal requires slightly different treatment and the treatment varies to some extent with the nature of the abrasive, grease, oil or dirt to be removed.

Lye and caustic have long been used for cutting greases and oils. But on some they work very slowly, and in all cases they are disagreeable and dangerous to work with and have a detrimental effect on soft or tarnishable metals. There are many cleaning compounds available at the present time which give very efficient service on certain grades of work. In the majority, however, some desirable features have been sacrificed to enhance the value of others.

Oakite Platers' Cleaner has been scientifically compounded, to combine the valuable qualities of the best cleansing agents and in it, all objectionable and detrimental features are eliminated or *nullified*. When properly used, O. P. C. insures a chemically clean base metal in unusually short time, avoids discoloration of metal, and provides better working conditions and eliminates danger to the workmen. O. P. C. will not "lead plate" on soldered articles. O. P. C. contains no filler and dissolves completely in water. It contains no inert material; every ounce is pure, effective concentrated cleaner of great lasting power, due to the fact that its action is physical rather than chemical, as with most cleaners. Every atom cleanses. For these reasons, the use of O. P. C. assures the minimum operating costs for the cleaning processes, and aids the other departments by avoiding the necessity of rebuffing, etc., and by decreasing the percentage of imperfect work.

The tank containing the cleaning solution should be equipped with a steam coil placed at the side nearest the workman, and should have a bottom draw off. When the steam coil is on the near side of the tank, the rise of water from it, by convection currents, continually sweeps across the surface and so keeps all floating oil and dirt at the further side. The steam coil should never be in the bottom of a tank. In this position it makes the cleaning out of a tank a very troublesome and dirty task.

After coming from a cleaning tank, the work should be well rinsed in clean cold water; continual running water in the rinse tank is advisable. After rinsing notice whether the water wets the whole surface of the work evenly, and will run off without breaking. This indicates a clean surface.

The electric cleaner is important, and is largely used under certain exacting conditions. Its use gives a chemically clean surface in a shorter time than by the ordinary method, and it diminishes tarnish on tender work. O. P. C. is without doubt the only Electric Cleaner that will give a chemically clean surface without the use of cyanide. The solution should be made up with 4 to 6 ounces O. P. C. to the gallon, depending on the work to be cleaned. The temperature should be at the very least 200° F., and a direct current of about 6 volts should be used. The current density should run about 50 amperes per sq. foot; O. P. C. makes an electrolyte of high conductivity and in small amount will easily let this current pass.

Sometimes on difficult work it is well to use a double throw switch and run direct current for a short time, then reverse for a few moments, and then finish with direct current.

The iron tank may be used as the anode, with the regular insulated frame and rod on top to take the work. It is better practice, however, to use sheet iron anodes about 6 inches wide. Rheostats are in most cases unnecessary, as high amperage is desired.

The current density should never be allowed to rise above 50 amperes per sq. ft., however (as might happen in a small tank where the electrodes are close together, or where a very strong solution affords unusually high conductance). Too much current will burn the grease or dirt on to the work and hinder, rather than facilitate its removal. In any case where this occurs, the use of a rheostat to cut down the current to a proper value, will remedy the trouble.

On soft metals the use of an electric cleaner is highly advantageous, as its use largely diminishes tarnish and pitting.

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## OTHER CLEANING AGENTS.

The combination of mineral salts, known as Oakite, in the form of a dry white powder, is too well known to need much description. It is the basis of all Oakite compounds; it contains none of the acids, lyes, sodas or caustics. It cleans by a purely physical action, being solely an emulsifying agent; and by avoiding saponification, the Oakite cleaners have a much longer life and act much more speedily than others. It is a very free rinser, a good electrolyte, and harmless to skin, fibres or metals.

There are some cases where a different or modified action is necessary from that of the O. P. C. cleaning bath.

For these special cases a specially developed

product is available as Oakite Composition No. 1, and Oakite Composition No. 2.

Oakite Composition No. 1 is a high-grade soap compound, carefully compounded for its specific purpose. It is made for cleaning aluminum and to supplement Oakite in the cleaning of soft metals, and for the removal of tripoli and rouge buffing from plated ware.

Oakite Composition No. 2 is a high-grade soap compound, similar to the No. 1 composition, but is much stronger in its action. It is used to supplement Oakite and O. P. C. and is specifically used for the following problems:

Removing smuts, heavy oils and greases from metals; removing sand-buffing material; removing burnt on oil, difficult japan, enamel, paint, shellac, varnish, etc.

A *cold* rinse, not a hot rinse, should follow cleaning in either soap compound, which may then be followed by a hot rinse if it is desired to make the work self-drying.

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## CLEANING BEFORE PICKLING.

Before the use of any pickle to remove scale, rust, corrosion, or tarnish from any metal, it should first be given a dip of 1 to 3 minutes in hot O. P. C. solution 8 oz. per gallon, followed by a rinse. The purpose of this is to prepare the surface for the action of the acid, by removing all foreign matter, such as oil, grease, and dirt, on which acid has no effect, and which would retard the pickle and make it uneven in

effect, and result in waste of acid and metal. This effects great saving in time and in acid bills; usually to the extent of 50% in large installations.

## CLEANING CAST IRON STOVE WORK, ETC.

O. P. C..... 8 Ounces, 212° F.
Water..... 1 Gallon.

For upkeep, add about 2 ounces O. P. C. per gallon per week, or as required. Time required for cleaning this class of work about 5 minutes in this solution. Then rinse in cold water and scrub with pumice. Repeat cold water rinse, then put in acid pickle (I part HC1, 8 parts $H_2O$). Then into cold water rinse and transfer to plating solution.

Scrubbing with pumice can be eliminated on this class of work by using two cleaning tanks. First place work in tank made up as follows:

O. P. C..... 4 Ounces, 212° F.
Oakite Composition No. 2.. 4 Ounces.
Ammonia.....¼ Ounce.
Water..... 1 Gallon.

Then rinse in hot water. Then into O. P. C. tank, then cold water rinse, then into acid pickle. Then repeat cold water rinse and transfer to plating bath.

## CLEANING LEAD AND ANTIMONIAL ARTICLES.

Use O. P. C. 6 ounces to gallon water. Keep boiling by steam coil. For upkeep add 1 to 2

ounces per gallon per week or as may be necessary. Time required for cleaning this class of work is from 3 to 5 minutes in still tank.

## ELECTRIC CLEANER ON LEAD AND ANTIMONY.

O. P. C..... 4 Ounces, 200° F.
Water..... 1 Gallon.

Use direct current of about 6 Volts. Time required in this solution from 1 to 2 minutes; then rinse in cold water and transfer to plating bath.

## CLEANING BRASS, COPPER OR GERMAN SILVER.

O. P. C..... 6 Ounces, 200° F.
Water..... 1 Gallon.

The upkeep is very small, depending upon the quantity of work turned out. Can be used with or without the electric current. Will not discolor or tarnish. Time required 1 to 3 minutes. In a still bath, the addition of one fluid ounce of ammonia daily, for every 10 gallons of solution is helpful in keeping the work bright.

## PREPARING TIN FOR NICKEL PLATING.

The best method is to use the Electric Cleaner, with direct current of 6 to 8 Volts.

O. P. C..... 6 Ounces, 200° F.
Water..... 1 Gallon.

Time required to clean this class of work in this solution 1 to 2 minutes. Then rinse in cold

water and transfer to nickel bath. In some cases, where the work is of unwieldy, large pieces, it would be advisable to just dip in a regular O. P. C. bath, 8 ounces to gallon water, 200° F. Then rinse in cold water, then scrub with lime or pumice. Then rinse in cold water and transfer to nickel tank.

## CLEANING OF DIE CASTING METAL FOR PLATING.

Place in solution of:

Water. . . . . 1 Gallon, 160° F.
O. P. C. . . . . 4 Ounces.

With or without electric current. Time required to clean this metal, with electric current (direct) 1 minute, then reverse ½ minute; without electric current about 3 minutes.

## JEWELRY.

**Cleaning off and Removing Shellac:**

To clean, place in solution of:

Water. . . . . 1 Gallon, 160° F.
Oakite Composition No. 1. . . . ½ Ounce.
Ammonia. . . . . 1 Ounce.

Time required in solution, to clean thoroughly, 1 to 3 minutes.

**Removing Shellac:**

Place in solution of:

O. P. C. . . . . 4 Ounces.
Water. . . . . 1 Gallon, 160° F.

Time required 15 minutes.

In some factories the line of work which is manufactured is such that the electric cleaner is far superior to any other, but in 75% of the factories it would be much better to put in the two tank cleaning system.

Tank No. 1:

| | | |
|---|---|---|
| O. P. C. | 4 | Ounces, 200° F. |
| Oakite Composition No. 2 | 4 | Ounces. |
| Ammonia | ¼ | Ounce. |
| Water | 1 | Gallon. |

Then rinse in hot water and then place in

Tank No. 2:

| | | |
|---|---|---|
| O. P. C. | 8 | Ounces, 200° F. |
| Water | 1 | Gallon. |

Just a minute in each of these solutions will clean almost anything well enough to plate without scrubbing. In very few cases would scrubbing be necessary.

## ELIMINATE CYANIDE.

Where a plater has a line of polished brass or copper to nickel plate, by cleaning this work in O. P. C. 6 ounces to gallon water, 200° F., he can make a great saving on cyanide by using muriatic acid, 10% solution, in place of a cyanide dip, as there is but slight discoloration of the metal when using O. P. C.

## CLEANING BEFORE GALVANIZING.

Use O. P. C. 8 ounces to gallon water. Keep boiling by steam coil and allow work to remain in this solution about 3 to 5 minutes; then rinse; then place in acid pickle; then rinse in cold water; then transfer to galvanizing bath.

If electric current is used 6 ounces O. P. C. to gallon water will give same results in 1 to 2 minutes' time.

## STOPPING OFF.

**Stopping Off:**

If certain parts of a metallic object are not to receive a deposit, as for instance, when a contrast is to be effected by depositing different metals in a pattern upon the same object, these parts are covered or stopped off with a varnish or wax. Stopping off varnish is prepared by dissolving asphalt, or damar with an addition of mastic, in turpentine. It is applied with a brush and allowed to dry thoroughly and then hardened in cold water. After plating, the "stop" is easily removed with O. P. C. 8 ounces per gallon or if asphalt, with O. P. C. and Oakite Composition No. 2, 4 ounces of each per gallon.

**Removing White Lead and Red Lead:**

Make up solution of:

O. P. C..... 8 Ounces.
Water..... 1 Gallon, 212° F.

Place work in solution for 3 to 5 minutes, then brush with hand brush, then rinse in cold water. Oakite Composition No. 2 is sometimes needed if it has set very hard.

**Removing Lacquer or Enamel:**

The ordinary lacquers such as are being used on brass chandeliers, etc., can be removed in

O. P. C. solution 8 ounces to the gallon of water 212° F. Time required for removal in most cases is 1 to 3 minutes. Where lacquer has been baked on with considerable heat it is an advantage to use O. P. C. and No. 2 Compound in these proportions:

| | |
|---|---|
| O. P. C. | 6 Ounces, 212° F. |
| Oakite Composition No. 2 | 6 Ounces. |
| Water | 1 Gallon. |

This will remove some enamels or lacquers in a few minutes. However, the better grades of lacquers or enamels, which are baked, will take from ½ to 1 hour.

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## STRIPPING.

This term is employed to denote not only an accidental loosening of the deposited metal, under the scratch brush or burnisher, but also an intentional removal of a deposit by means of acid.

All work must be carefully cleaned (and any lacquer or similar protective coating must be removed) before stripping, in the same manner as for plating, using O. P. C. 8 ounces per gallon. A uniformly clean surface is necessary, to allow the acid to act evenly.

Silver is stripped from old plated work on copper and its alloys, before they can be replated, by immersing the plated article in hot concentrated sulphuric acid, and adding from time to time a few crystals of saltpeter. The

acid must be made hot, the articles to be stripped must be quite clean and dry before immersion, and must be moved about while adding the saltpeter. If this is done as directed, the whole coat of silver may be loosened without serious damage to the metal beneath. The same operation may be performed in a cold mixture, composed of 1 part strong nitric acid added to 10 parts of sulphuric acid in a stoneware vessel. The goods to be stripped in these acids should be first attached to stout wires, as they must be frequently moved about in the solution, and taken out to be examined from time to time, to prevent overdoing the process and injuring the metal beneath the coat. When all the silver has been stripped off, the article must be at once rinsed in clean water to free it from acid; but should it be necessary to reimmerse the article, it must be first dried, since the presence of water in the acid will cause it to attack the metal beneath the coat of silver. When the plated article is made of iron, steel, zinc, pewter, lead, or white metal, it must not be immersed in the stripping acid, but should be desilvered in a solution of cyanide of potassium by means of a current from a battery or a dynamo. An old disused plating solution will do very well for this purpose if it has plenty of free cyanide. Immerse the article to be stripped, and connect it as an anode to the positive pole of the battery or dynamo, and suspend a plate of carbon or a strip of platinum foil in the solution as a cathode. Then pass a strong current

until all the deposited coat of silver has been dissolved. Gold may be removed from gilded articles by a similar method in an old gilding solution. Gold may also be stripped from base metals by immersing them in hot nitric acid and adding some common salt as required. This operation is similar to the acid process for stripping silver, and needs equal care. Nickel is stripped from nickel-plated articles in a mixture composed of 1 pint of water, 1 pint of strong nitric acid, and 4 pints of strong sulphuric acid. The water must be first placed in a lead-lined vessel, or in one of enameled iron, and the sulphuric acid added gradually and carefully, as the addition of this acid to water raises its temperature to a boiling point. When the sulphuric acid has been mixed with the water, the mixture must be poured into a stoneware dipping pan and the nitric acid added. These precautions are necessary, because the mixture of the two acids and water will dissolve lead and enamel, but will not pierce acid-proof stoneware, whilst this in turn will not stand sudden expansion caused by the heat generated in mixing the sulphuric acid with water. All operations in stripping by acids must be performed in the open air, or under a hood with good draft. The process must be closely watched throughout and the article immediately removed, once its coat has been stripped off. The time required for stripping runs from a few minutes to half an hour.

## ELECTRICAL REQUIREMENTS NECESSARY IN A PLATING ROOM.

In the first place it is better to buy a first class dynamo; even though it be a little more expensive in the beginning, it will prove to be the cheapest in the end. The dynamo should be set up on a good solid foundation and as near to the tanks as convenient, and should be placed so that the plater will have easy access to all its working parts. A few minutes' attention given to the dynamo each morning adds greatly to efficiency, and will keep commutator and brushes in good condition. Be sure the dynamo rests firmly on its foundation. Great care should be taken in adjusting the brushes not to have too much pressure on commutator. The brushes should not bear too hard on commutator, but just enough to insure perfect contact between brush-holder and rod. If commutator shows signs of roughness, smooth with fine sand-paper, and lubricate with vaseline. Never use emery paper. The conducting bars running from the dynamo past the various tanks in the plating room should be large enough to carry all current that the dynamo gives without heating, and the various vats can be connected by means of wires or rods leading from the conducting bars. Great care should be taken to have the wires of a sufficient size so as not to lose too much power in overcoming resistance. The current must be regulated for each tank by a resistance switch

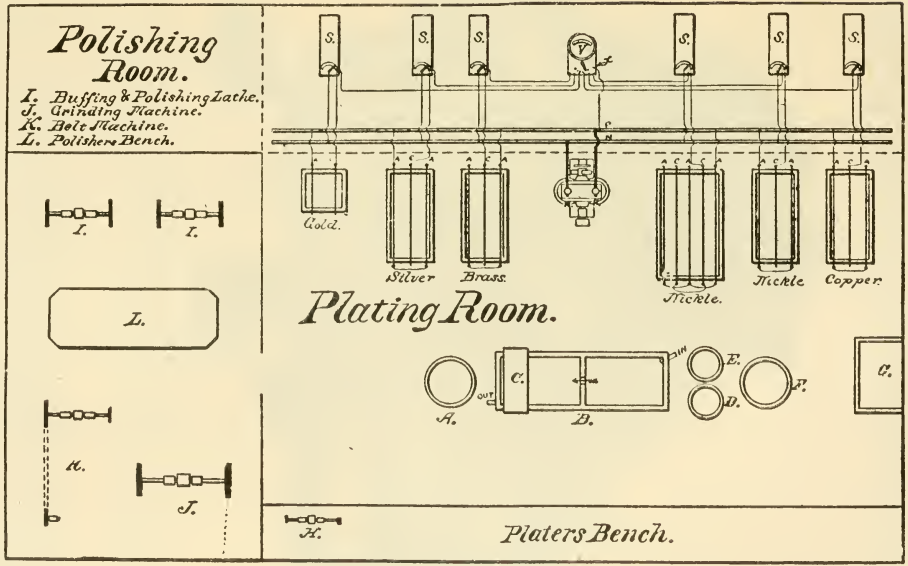


Fig. 1—Plan View of a Modern Plating and Polishing Room

or rheostat connected to the positive bar and also to the positive bar of the tank. Rheostats

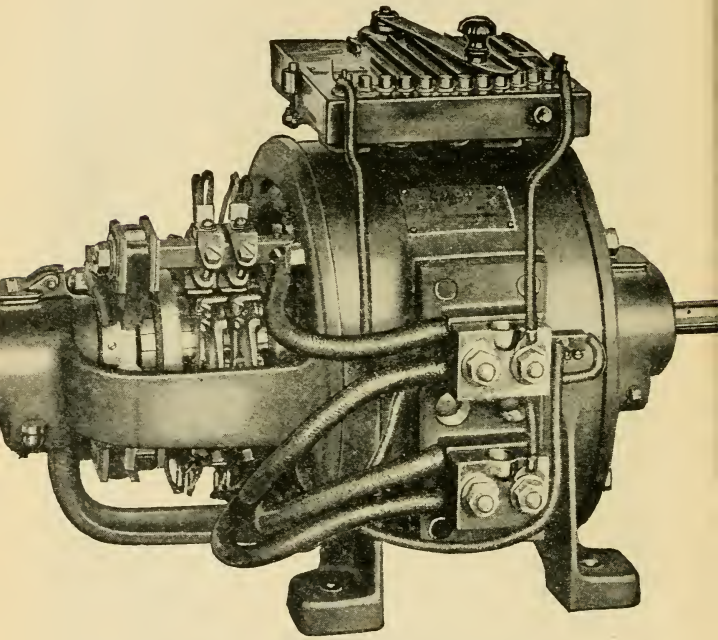

Fig. 2—Electro-plating Dynamo.
Manufactured by General Electric Company, Schenectady, N. Y.

are put up as near to the tank as possible, and should be shut off while putting work into tank, and then be turned toward the strongest point until a suitable current is obtained.

It is quite essential in a large plating room to have a voltmeter, and also an ampere meter, which will show the plater the exact amount

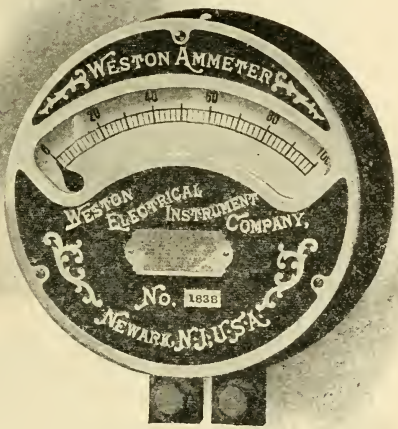


Fig. 3—Ammeter for Electro-plating Work.
Manufactured by Weston Electric Company, Newark, N. J.

of current he is getting. By means of an accurate ammeter, the amount of metal actually deposited can be determined.

## NICKEL PLATING.

The solution should be made up by dissolving ¾ of a pound of nickel-ammonium sulphate

(double nickel salts) in 1 gallon of water, which will bring the density up to about 6° or 7° Bé, and adding a small amount of boric acid, making a fine, bright nickel. In some instances, agitated solutions are of great importance, for the reason that a higher current density may be used, and so decrease the time, prevent pitting; the work will come out just as bright as in a still solution.

**Anodes:** Anodes are very important in nickel solutions, owing to the fact that the solution does not readily dissolve the metal, as this action takes place only by the aid of the current, and as nickel sulphate will not conduct electricity easily, and as ammonium sulphate will, we have combined them and make the double salt, and the free sulphuric acid liberated by the deposition immediately passes to the opposite pole, and attacks the anodes. A large anode surface is necessary. Cast anodes are preferable, as rolled anodes are so hard that more current is required.

**Bath:** The bath should be slightly acidic. This condition can be readily told, by testing with litmus paper. Blue litmus paper is colored red by acid, and red litmus paper is colored blue by an alkali. Too much acid will cause peeling, and if the bath is alkaline a dark deposit will be obtained. The solution should be kept always at 6½ to 7° Bé.

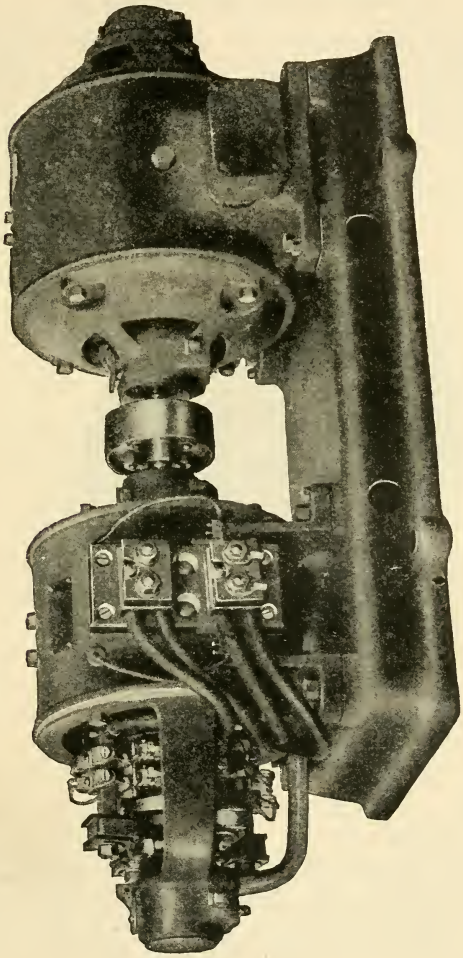

Fig. 4—Motor-generator Set.
Manufactured by General Electric Company, Schenectady, N. Y.

### To Plate Nickel on Aluminum.

Polish, clean (using No. 1, 2 ounces per gallon), followed by Oakite (¼ ounce per gallon), rinse in cold water, dip into concentrated nitric acid, rinse in cold water, dip into: water, 1 gallon; iron chloride, 1 ounce; muriatic, ½ ounce; and from this dip rinse quickly and place

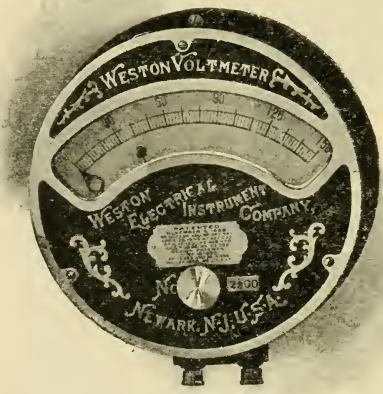


Fig. 5—Voltmeter used in Electro-plating.
Manufactured by Weston Electric Company, Newark, N. J.

directly in nickel solution. Plate with heavy current for 2 minutes, and then reduce current. Nickel solution: water, 1 gallon; single nickel salts, 8 ounces; Epsom salts, 3 ounces; boric acid, 1 ounce; common salt, ½ ounce. Plate with 4 volts at 80° F.

## COPPER PLATING.

**Copper Solution:**

| | | |
|---|---|---|
| Warm water | 1 | Gallon. |
| Sodium cyanide 96/98% | 3½ | Ounces. |
| Copper cyanide 70% | 3 | Ounces. |
| Soda ash 58% | 2 | Ounces. |
| Sodium hyposulphite | ¼ | Ounce. |

Copper cyanide contains 70% metal and 30% cyanogen, so a solution prepared as above will contain 2.1 ounces of copper in the form of metal per gallon of solution. If dense solutions are required the metal content may be increased 3½ to 4 ounces per gallon with the other materials in proportion. In replenishing copper solutions with copper cyanide the following proportions will equal 2 pounds of sodium cyanide and 1 pound of copper carbonate:

| | | |
|---|---|---|
| Hot water | 2 | Gallons. |
| Sodium cyanide | 12 | Ounces. |
| Copper cyanide | 11 1/3 | Ounces. |
| Soda ash 58% | 4 | Ounces. |

Copper carbonate consists of 50 per cent. metal and copper cyanide consists of 70 per cent. metal.

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### To Plate Copper on Aluminum.

Polish, clean, dip in hot O. P. C. (½ pound per gallon), rinse and immerse few moments in 5% hydrofluoric acid solution. *Shake* acid from work well, and plate directly. Bath: water, 1 gallon; copper sulphate, 1½ lbs.; sulphuric acid, 2 ounces; black molasses, ¼ ounce. Use

wooden, or lead, or asphaltum lined container for hydrofluoric acid.

## COPPER PLATING AND CLEANING IN SAME SOLUTION.

| | |
|---|---|
| Water | 24 Gallons. |
| O. P. C. | 12 Pounds. |
| Copper Cyanide | 12 Ounces. |
| Sodium Cyanide | 24 " |

First, dissolve the O. P. C. in the water; second, take up the copper cyanide with the sodium cyanide; third, add the copper and sodium cyanide to O. P. C.

Use an iron or steel tank. Keep boiling with steam coil near side of tank. Use copper anodes and from 6 to 8 volts pressure.

## BRASS PLATING SOLUTION.

The brass plating solution seems to be the most difficult of all solutions to handle, and there are several ways of running a brass solution for various kinds of work, and if a man has had a little experience in brass plating he will readily understand what kind of a solution is needed for the work he is about to plate. In my experience I have used several different brass solutions, and have plated several kinds of metals in different lines of work, and I find that in plating lead work or any white metal, that a solution made up of about

| | |
|---|---|
| Warm water | 1 Gallon. |
| Sodium cyanide 96/98% | 9 Ounces. |

Copper cyanide 70%..... 5 Ounces.
Zinc cyanide 55%..... 2 Ounces.
Soda ash 58%..... 4 Ounces.
Ammonium chloride.....1/3 Ounce.

with a small amount of white arsenic dissolved in caustic soda, and a small quantity of ammonia, will bring very good results.

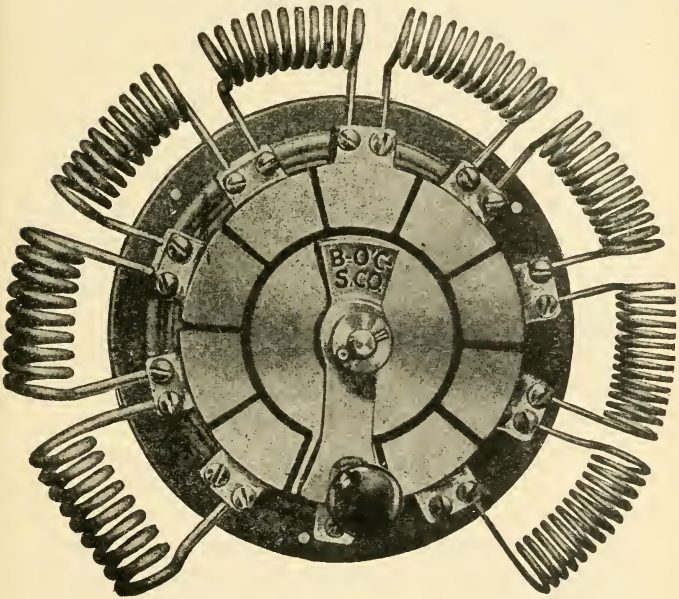


**Fig. 6—A Rheostat used in the Plating Room**

In preparing the solution use one-third of the total capacity of the tank in gallons, heat to a temperature of 120° F.; first, add the cyanide,

then copper, then zinc and soda ash and finally balance of cold water to make up the quantity of the solution required. Finally add the chloride of ammonium. Mix thoroughly and electrolyze the solution.

Care should be taken in using the arsenic, not to add too much. A very small amount is sufficient, and when this solution is tried, if it does not work nice and clear, simply add a little more ammonia.

In replenishing brass solutions proportions given for copper solution may be used very satisfactorily. The successful brass plater uses very little zinc in his solutions when once prepared. Very small proportions of caustic soda or aqua ammonia (¼ ounce per gallon) will keep a permanent reduction of the zinc in solution with small additions of zinc cyanide.

The addition of free cyanide to a solution should be determined by anode conditions. Never add more than ½ ounce of cyanide as free cyanide per gallon of solution at any one time.

## ZINC PLATING.

The electrolyte or zinc solution can be made up from sulphate of zinc (white vitriol) or from chloride of zinc, or from a combination of the two. An addition of conducting salts, such as sulphate of sodium, sulphate of aluminum, chloride of ammonium, etc., can be used to increase the conductivity of zinc solutions. There

are also a number of organic and inorganic chemicals recommended for the purpose of producing a more dense and brighter deposit. The majority of these chemicals act as a colloid. The following solution has been worked with success in an open still tank:

| | |
|---|---|
| Zinc sulphate | 200 Ounces. |
| Sulphate of sodium (crystals) | 20 Ounces. |
| Sulphate of aluminum | 10 Ounces. |
| Boric acid | 3 Ounces. |

Water to make 7 gallons.

An addition of a few ounces of zinc chloride, or instead an ounce of hydrochloric acid, will improve the solution to some extent; also an addition of grape sugar will improve a sulphate of zinc solution and produce a smoother and more uniform finish.

The above solution can be successfully used for all kinds of articles, including wire, band iron, sheets and wire cloth, and will produce by three volts and about twenty amperes per square foot a white, smooth deposit in thirty minutes which will stand three one-minute copper tests.

Chloride of zinc solutions can also be used to better advantage in open tank work, as well as in mechanical plating machines. A good solution is composed of the following:

| | |
|---|---|
| Zinc chloride | 10 to 15 Pounds. |
| Chloride of ammonia | 5 to 7.5 Pounds. |
| Grape sugar | 1 Pound. |

Water to make 10 Gallons.

In the open bath a low potential is used, about 3 volts being required with a current of 12 to 15 amperes per square foot of work surface, the density of the solution being about 20° Baumé, although a higher voltage can be used if it is desired to shorten the time of deposit. For mechanical apparatus, where a revolving container is used, the solution is brought to a density of 25° to 30° Baumé and 8 to 10 volts are used, with a corresponding increase in current.

## PLATING ON ALUMINUM.

In plating aluminum, one method is to dip in 5% hydrofluoric acid after cleaning, then into a mixture of 100 parts of sulphuric, 75 parts nitric acid (both concentrated). After rinsing with water, the surface is immediately plated with zinc, on which any other metal may be plated.

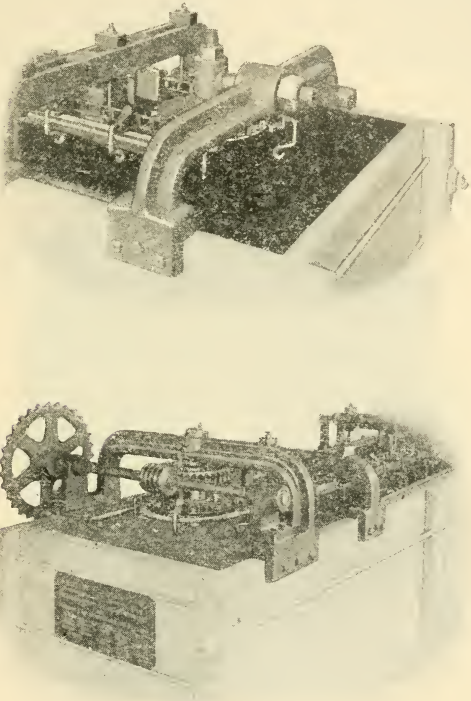

Fig. 7 and 8—Two Views of the Patent Automatic Moving Plating Tank manufactured by the U. S. Electro-Galvanizing Company, Brooklyn, N. Y.

## TUMBLING BARREL PLATING.

Tumbling barrels have almost entirely done away with wiring or basket plating for small work such as screws, collar buttons, etc., and at the present day they turn out this class of

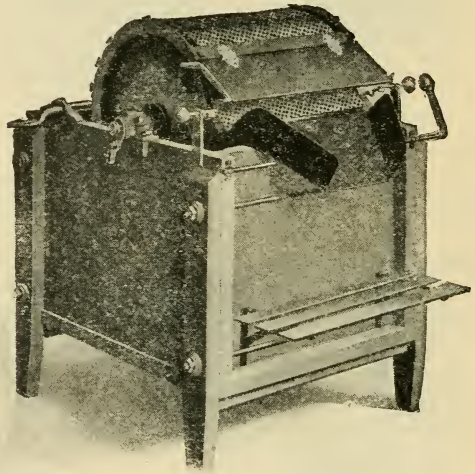

Fig. 9—The U. S. Junior Plating Barrel made by the U. S. Electro-Galvanizing Company, Brooklyn, N. Y.

work in tumbling barrels in large quantities and in this way reduce the cost to a much smaller figure than when it was done by the old method.

A very good brass solution for tumbling barrel plating is made as follows:

| | |
|---|---|
| Water | 1 Gallon. |
| Sodium cyanide 96/98% | 15 Ounces. |
| Copper cyanide 79% | 8 Ounces. |
| Zinc cyanide 55% | 4 Ounces. |
| Soda ash 58% | 6 Ounces. |
| Caustic soda 78% | 1 Ounce. |

Aqua ammonia in amounts of ½ ounce and upwards may be used to bring up a uniform brass deposit. Prepare the solution in the order

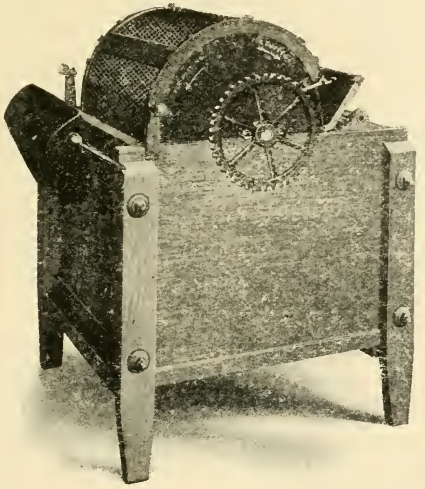

Fig. 10—Another View of the U. S. Junior Plating Barrel.

given and the replenishing should be accomplished on a similar basis. Ammonia and arsenic may be added in small proportions to brighten deposits as required.

## SILVER PLATING CASKET HARDWARE.

The work is first wired or racked up, then it is dipped in the O. P. C. and rinsed off in clean water, nicked plated for about five minutes, rinsed in clean water, put into the silver strike solution for a minute or two, then into the bright silver solution, where it is usually run for about five minutes. This class of work must come out of the silver solution bright and clear, and without stain, as some of the cheap work goes through without any buffing, and the work that is to be buffed has to be done simply by color buffing. When the work comes out of the silver solution it should be rinsed in cold water and then in hot water, and then hung in an oven at 150 to 200° F. until thoroughly dry. It is then ready for buffing. The O. P. C. solution for this class of work should be made up as follows: O. P. C., 4 ounces to gallon water, with electric current at about 6 to 8 volts pressure.

The nickel solution should be made of ¾ pounds of double nickel salts to a gallon of water, and should stand about 6° to 7° Bé. A small amount of table salt added to this solution occasionally will whiten the deposit. The silver strike solution should be made up of about 10 ounces cyanide of sodium to the gallon, and ½ ounce silver chloride to a gallon of water. The silver solution should contain 2 ounces of silver chloride and about 12 ounces of cyanide of sodium per gallon of water; add bisulphide

of carbon in the usual manner to brighten deposit. Care should be taken in adding this brightener, as too much will give very bad results. A few drops of the bisulphide of carbon just as purchased, without dissolving at all, added to a silver solution each morning, — stir the top of solution and repeat at noon when using solution all the time, — is better than any other method for this line of work.

## SILVER PLATING STEEL KNIVES.

The knives are first placed in a basket, and then washed in a solution of O. P. C., 4 ounces, and Oakite Composition No. 2, 4 ounces, to gallon of water boiling, then hot and cold water rinsed, then placed in a solution of Oakite (4 ounces to the gallon) to prevent rust, and scoured with fine pumice, rinsed in clean water and racked up.

Then dip in dilute sulphuric acid dip in proportion of 1 part of acid to 8 parts of water, then rinse in clean water and hang into a steel strike. The steel strike is made up of

Carbonate of copper.....10 Grains.
Chloride of silver..... 5 "
Cyanide of sodium.....10 Ounces.
Water..... 1 Gallon.

Use copper anode 2 x 8 inches in cloth bag.
Silver " 1 inch square.

It is advisable at the end of each week to take out about 1 gallon of the strike solution and add about 1 quart of silver solution and cyanide enough to keep the solution standing

10 Bé. Never add any copper to the strike after first making, as all the copper required is obtained from the anode. After striking the knives in steel strike, they should be rinsed in clean water, and struck up in the regular silver strike, and from there into silver solution. The silver solution should always stand about 15° to 18° Bé, and have 4 to 4½ ounces of chloride of silver per gallon, and 15 to 20 ounces of cyanide of sodium per gallon. It is best to keep the knives in motion while plating by means of a swing frame attached to the negative pole, which is the plating pole. A scale attachment which will register the amount of silver being deposited can also be obtained.

## SILVER PLATING HOLLOW WARE.

### Brass, Copper, or German Silver.

The work is first placed in O. P. C. solution 8 ounces to gallon water kept boiling with a steam coil. Time required in cleaning solution about 1 to 3 minutes. Then rinse in cold water, scour with fine pumice on a tampico brush or wheel, allowing a steady drip of water to flow on the brush while the work is being scoured, so as to keep work wet, then sponge off thoroughly in clean water and hook or wire up, when it is ready for plating. The work is then hung in a clean water vat until the plater is ready to handle it. On removal, dip work in O. P. C. solution, 6 ounces to gallon water, 200° F. Then cold water rinse, then into mer-

cury dip, rinse in clean water and then dip in O. P. C. solution. Then into a weak cyanide of sodium dip and from this into silver strike solution, where it is struck up for a few minutes, and then into silver solution, where it remains until the desired amount of silver is deposited. This method is for work that is satin-finished or burnished.

If the work is only to be buff-finished, a different method should be used in cleaning, as this class of work is only burnished on such parts as cannot be readily reached by the buff. Therefore use a solution of O. P. C. 6 ounces to gallon of water 200° F. Place work in O. P. C. solution for about 2 minutes, wash off with a Canton flannel brush, scour only such parts as inside of tea pots, or under handle, etc. Then plate in a bright silver solution. For satin-finish or burnished work it is best to use a solution composed of

| | | |
|---|---|---|
| Water | 1 | Gallon. |
| Silver cyanide 80½% | 2½ to 3½ | Ounces. |
| Sodium cyanide 96/98% | 3¼ to 5¼ | Ounces. |

**Bright Silver Solution:**

| | | |
|---|---|---|
| Water | 1 | Gallon. |
| Silver cyanide 80½% | ¾ to 2¼ | Ounces. |
| Sodium cyanide | 6 to 8 | Ounces. |

The metal content of silver solutions may be varied from ½ ounce metallic silver to 6 ounces per gallon of water for quadruple plate upon britannic goods. Ordinary silver solutions for

brass goods average 2 ounces metal per gallon of water.

## SILVER PLATING LEAD OR SPELTER ARTICLES.

The best results can be obtained by first washing the articles in a solution of O. P. C. 4 ounces and Oakite Composition No. 2, 4 ounces, to gallon water, 200° F. Time required to clean in this solution 1 to 3 minutes. Then rinse in hot water; then they should be hooked or racked up and dipped in the O. P. C. solution of 6 ounces O. P. C. to gallon water 200° F. Then rinse in cold water, and strike in cyanide copper solution for a couple of minutes, and nickel plate about ½ hour. Then rinse in clean cold water, dip in O. P. C. solution and then cold water rinse, then place in silver strike solution, for a couple of minutes, and plate in the ordinary silver solution until the desired amount of silver is deposited. The reason for nickel plating is only to save silver. For instance, when an article for French Gray finish is relieved, one is liable to cut through on some little part, and if a nickel base is under the silver, it in most cases would not be noticed.

## ARGENT IVORY OR SILVER WHITE.

This is an exceptionally fine white finish, burnished on certain parts, and is produced in

the silver solution by running the work just long enough to get a dead white, and rinsing in cold and hot water, and then in cold again, and dry in soap suds or alcohol, and then burnish using Okemco Burnishing Soap (one lb. to 8 gallons of water) for the burnishing. In this way one is not so liable to stain the work. Or burnish dry, which in some cases is preferable as this finish stains very easily. This white finish should be lacquered with a pure white celluloid lacquer.

## OLD IVORY FINISH.

This is a beautiful finish, and can be produced in several ways. One can get a very fine finish by using white enamel lacquer and spraying it on the work, and when dry apply with a camel's hair brush, burnt umber ground with oil and thinned with turpentine until the shade desired is obtained. A small amount of burnt umber to about 6 to 8 ounces of turpentine will give a fine tan color, which is a very fine color to apply on the white. Rub off with turpentine with a small piece of felt or chamois. A still better way to produce this Old Ivory is to produce the white in the silver solution, run the work just long enough to get a dead white, and then rinse off in cold and hot water, and then in cold water, and then dry in alcohol or soap suds and lacquer. Apply burnt umber as before.

For the cheap class of work the cost of this finish can be reduced by first running the work

in an acid copper solution for about ½ hour which will give a dead finish. Then silver plate. In this way the dead white is produced in about half the time in silver solution, thus saving silver.

---

## ROSE GOLD.

Rose gold finish is a beautiful finish on almost any kind of work. There are several ways of producing this finish. For instance, if one wants a fine rose finish on high class jewelry, one can produce the smut by the use of an old gold solution, to which may be added a small amount of caustic potash, and use carbon anodes. I have found that adding carbonate of copper taken up with yellow prussiate of potassium in small quantities will give a very fine red rose. Run work in this solution for a couple of minutes, then rinse in a weak cyanide of sodium dip, then relieve with bi-carbonate of soda, and then run into a roman gold solution, which consists of

2 Ounces of C. P. cyanide of sodium,
1 Gallon of water,
5 Pennyweights of fulminate of gold.

For cheap classes of work one can produce a rose finish which is very inexpensive, and which is also a very nice finish by producing the smut in an acid copper solution, and then relieving with bi-carbonate of soda, and gold plating in a roman gold solution. I have also

had success by using a dip gold solution made up of

1 Gallon of warm water,
5 Pennyweights fulminate of gold,
2 Ounces C. P. cyanide of sodium,
2 Ounces phosphate of soda,
1 Stick caustic potash.

---

## GILDING INSIDE OF SPOONHOLDERS, CUPS, CREAM PITCHERS, ETC.

**Gilding Solution:**

Water. . . . . 1 Gallon.
Cyanide of sodium.. 8 Ounces.
Fulminate of gold... 10 Pennyweights.

Fill cup with gold solution and hang anode in cup until desired color is obtained. In a case such as a cream pitcher with a lip on it, to gold line so that when cup is filled with solution it does not cover all parts that are to be gilded, the proper way to gild such a piece of work is to have a tight rubber band to place around the top so as to hold solution up to highest point in order to gild the lip, — Or use wax which by some silver concerns is called "Gilders' Wax." This wax should be heated in warm water until it becomes soft, so that it can be stretched out in any length or width desired, and placed on work while warm. In this way one can gild any piece of work no matter what shape it may be. For instance, take 25 cups with an uneven surface on top, — heat a lump of this wax, enough to place over

the lip of these 25 cups, and by the time the wax is on all of them, the first will be cool enough to proceed with the gilding. Then when all are gilded the wax should be taken off by placing in warm water, when it can be easily removed. Care should be taken not to have the water too warm.

**Gilders' Wax.**

White Wax ..... 1 Pound.
Rosin..... 2 Pounds.
Mix by heat.

---

## GOLD PLATING 14 OR 18 KARAT COLOR ON JEWELRY.

I have found that there is but one way to make these solutions, and obtain first class results, and that is to purchase a 14 Karat anode, and run the gold into a cyanide solution by using a porous cup until one has drawn off about 10 pennyweights of the anode into 1 gallon of C. P. cyanide of sodium solution. Have the solution stand about 6° Bé. In this way a beautiful 14 to 18 Karat color is obtained which will run very even. The richer the solution in gold, the richer the color obtained. Therefore, when the solution is first made up with 10 pennyweights to the gallon, one will get about an 18 Karat color, and as the solution is used it will go down to a 14 Karat, and one can get about any shade from a copper color to almost a 22 Karat in this way.

## DARK BROWN ON COPPER OR BRASS.

| | |
|---|---|
| Water | 1 Gallon. |
| Chlorate of potash | 3 Ounces. |
| Sulphate of copper | 3 " |
| Hyposulphate of soda | 3 " |
| Acetate of copper | 3 " |

Use hot. In some cases sulphate of nickel may be added.

## BRIGHT FOR SILVER.

| | |
|---|---|
| Chloroform or ether | 2 Ounces. |
| Bisulphide of carbon | 4 " |
| Silver solution | 2 Quarts. |

## GREEN GOLD.

A very fine green gold color can be produced in a solution of

10 Gallons of water,
10 Pennyweights of fulminate of gold,
20 Ounces C. P. cyanide of sodium,
3 Pennyweights chloride of silver,
2 Grains acetate of lead.

### Ormolu Gold Finish on Lead Work.

The first thing to do is to see that the work is properly cleaned, and a very good way to clean this kind of work is to wash with a solution of O. P. C. 4 ounces, Oakite Composition No. 2, 4 ounces, to gallon water 200° F. Time required to clean this class of work 1 to 3 minutes. Then rinse in hot water. Then wire or rack up the work, dip in O. P. C. solution (6 ounces O. P. C. to gallon water) 200° F., rinse in cold water, then transfer to bright cyanide

copper solution until coated all over with copper, then hang into an acid copper solution for from one to two hours, according to the class of work being done; then dip into bright dip composed of 1½ parts oil of vitriol, 1 part nitric acid. Then rinse off thoroughly in clean water, and hang in brass solution until a nice yellow brass is obtained. About 2 or 3 minutes is sufficient. Then gold plate in salt water gold solution.

Brass solution to be used at a temperature of 80° F. in connection with salt water gilding solution.

| | |
|---|---|
| Water | 1 Gallon. |
| Sodium cyanide 96/98% | 4½ Ounces. |
| Copper cyanide 70% | 3 Ounces. |
| Zinc cyanide 55% | 1 Ounce. |
| Soda ash 58% | 2 Ounces. |
| Ammonium chloride | 1/3 Ounce. |

Prepare in order given. Brass anodes of 80% copper and 20% zinc give best results in brass solution.

The salt water gold solution should be made up of

8 Ounces yellow ferrocyanide (yellow prussiate of potassium),
24 Ounces carbonate of sodium,
16 " phosphate of sodium,
3 Pennyweights fulminate of gold,
1 Gallon of water.

In setting up this solution, use a red porous jar, and a copper kettle; place the jar in the kettle and place a piece of sheet zinc around

the porous jar. The sheet zinc should be about ½ inch thick. A copper rod should be attached to the zinc with rivets so as to get a good con-

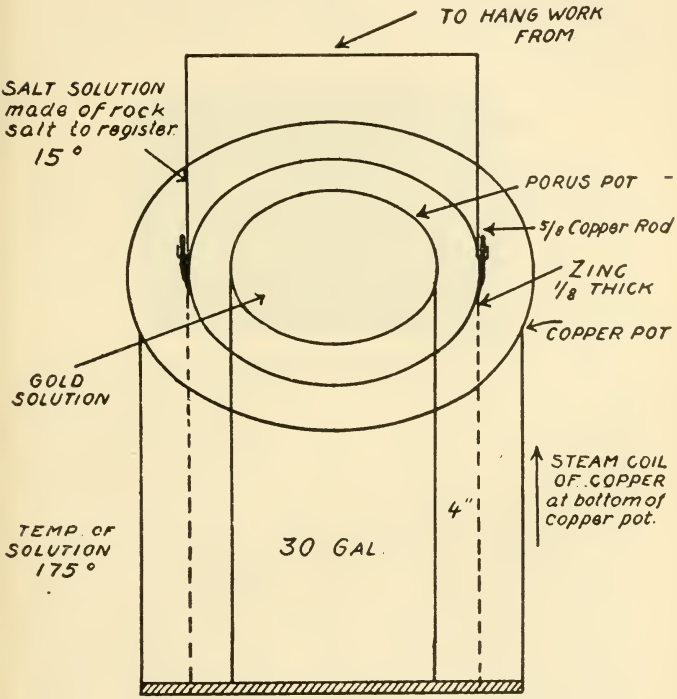


Fig. 11—The Outfit for Salt Water Gilding.

nection. Stand the porous jar and zinc on either wood or glass in the bottom of the copper kettle. The salt water which is used to

form battery should be made from rock salt (which is very cheap), and a little sal-ammoniac, and should stand about 12° to 15° Bé, and should be heated with a copper coil.

Be sure and use copper or brass coil.

---

## SOME TALK ON LACQUER.

First be sure the work to be lacquered has been thoroughly cleaned. A room free from dust should be fitted up with an oven heated to 140° F. and supplied with a chimney or some means of carrying off the fumes of the lacquer, which are very disagreeable.

For dip lacquering the lacquer is placed in an iron enameled vat. The articles perfectly clean are hung on hooks and dipped into the vat and held up for a few minutes to allow the superfluous liquid to run off. Then they are hung up to dry in the oven. Dip lacquers are best thinned at night which will allow time to thoroughly blend. It is impossible to use a single solvent for an all around lacquer. Dip work requires one rate of evaporation, and spray work another rate. This is regulated by the solvents used and the proportions of each, and only experience can teach it. Brush lacquer is the same as dip lacquer except that it should be used with a thicker body so it will spread well under the brush. A fitch or camel's hair brush should be used.

The proper preparation of lacquer solvents calls for the highest degree of skill and care. The solvents must be prepared water white and free from water and acid. Lacquer will attract moisture from the air in a damp room, and thus cause considerable trouble. Lacquered work which is thoroughly dried in an

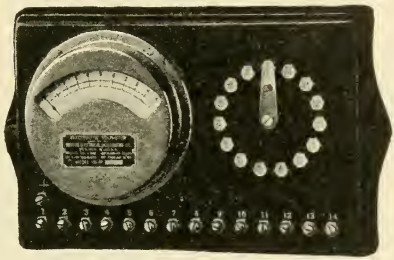

**Fig. 12—Rheostat and Wattmeter.**
Manufactured by Western Electric Company
New York and Chicago

oven will be softened up again if a lot of newly lacquered work is put in with it.

For work that requires a heavy coat of high gloss lacquer, additions of various gums are made, some for hardness, some for gloss, and some for adhesion. Each in its proper proportion, and each with a certain amount of proper solvent to carry it. Some solvents precipitate some gums, and their relative evaporating points are to be considered. Gum lacquers unless a very heavy coat is required may be thinned out with three or four parts of thinner. If heavy coats are required they should be dried with considerable heat to harden them. A thoughtful, careful workman

will obtain far better results with a fair grade of lacquer, than a careless workman will with the best grade.

## THE USE OF WATER DIP LACQUERS.

This name is applied for the reason that after the article has been plated and without drying it can be dipped into the lacquer without in any way injuring the finish. These lacquers are very beneficial for bright dipped finishes that are used in basket work. Also mat finish work on sheet brass, etc. Such work would tarnish at once if dried and then lacquered, and for this reason must be lacquered as soon as the dipping method is over.

For instance, sheet brass that is to be mat finished and dipped through bright dip often causes lots of trouble if one stops to dry it before lacquering. On the other hand if this work is dipped through a hot solution of Oakite Composition No. 1 and clean hot water, and then dipped into lacquer, there will be no trouble whatever. The dip lacquer for this class of work should be used very thin so it will run off without leaving a drip. I have lacquered thousands of pieces of this class of work in this way, and have had very good results.

The water should be removed every day either by syphon, or by means of a faucet at the bottom of tank. A wire screen nickel plated with a coarse mesh should be placed a few inches from the bottom of lacquer tank.

All dirt, etc., carried into the lacquer will sift through the screen, and can be drawn off with the water.

## THE USES OF AIR BRUSHES.

The most up-to-date method of lacquering at the present time seems to be with the air brush called the "Sprayer," which is operated

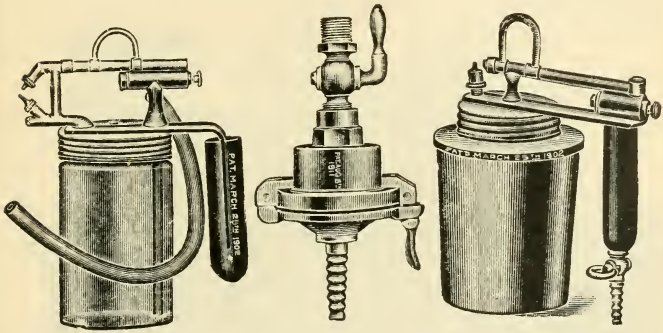

Fig. 15—Sprayers and Air Filter.
Made by Eureka Pneumatic Spray Co., New York

by compressed air, and everything from the largest to the smallest object can be lacquered or painted by means of this "Sprayer."

There are all styles of sprayers, some for lacquers and some for enamels, etc., and any number of colors can be blended together by use of the air brush. This method is far superior to the old way of using a camel's hair brush. The lacquer or enamels spread better and one can obtain a smoother surface. It also saves labor, as more work can be turned out in this way. Four or five pieces of work

can be turned out with the spray while doing one with a brush, and at the same time give better results. It is a very good idea to use a hood, paint receiver and exhaust fan in connection with the "Sprayer" to remove the vapors which may arise. A pressure regulator and filter are also beneficial for fine work.

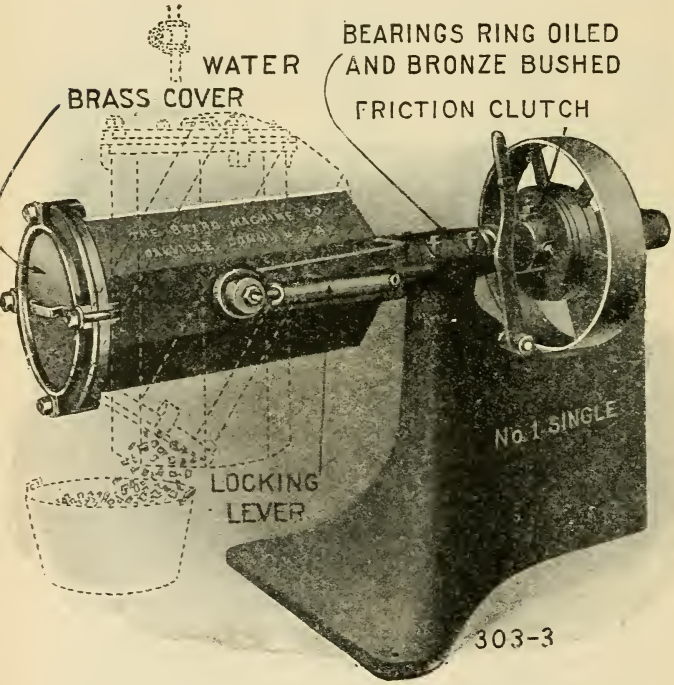


Fig. 13—Steel Ball Burnishing Barrel (single). The cut shows barrel in working position. Made by Baird Machine Company, Bridgeport, Conn.

## BURNISHING WITH STEEL BALLS.

This method of burnishing small metal articles in tumbling barrels is a method of mixing articles such as buckles, chains, collar buttons, etc., with steel balls in the proper proportion

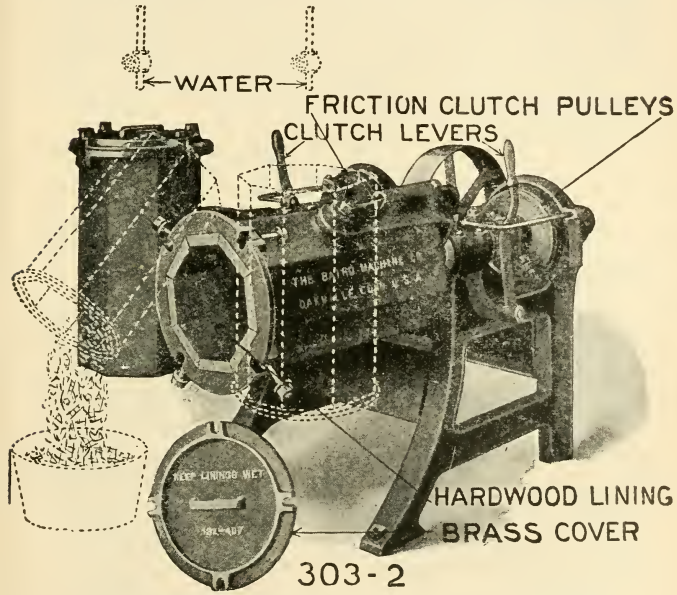


Fig. 14—Double Burnishing Barrel for Use with Steel Balls. Made by The Baird Machine Company, Bridgeport, Conn. The cut shows one Barrel horizontal and the other in position for dumping

and rolling together in a thin solution of Oakite Composition No. 1, or Okemco Soap, depending on the work. The balls required must be hard and smooth. Small articles can be burnished and handled in large quantities in this way at a very small expense.

I have burnished rose and green gold buckles in this way when I only wanted them to be burnished on the high lights and by tumbling them thirty minutes I got out very near the same class of work as I would had they been hand burnished, and the cost when the work is handled in this way is very small.

Care should be taken not to allow the steel balls to become rusty.

---

## FORMULAS.

### Gun Metal Finish.

On dip brass, copper, german silver, etc., or on any metal:

Make a saturated solution of cyanide of sodium and arsenic, and use iron anodes and ordinary current.

To make this solution, boil the arsenic and cyanide together in about 2 gallons of water to 1½ pounds of cyanide and 1 pound of arsenic, which will when dissolved, be about saturated. If not, add a little more arsenic. Do not inhale the fumes as they are very poisonous.

**Acid Copper Solution:**

| | |
|---|---|
| Water | 1 Gallon. |
| Sulphate of copper | 32 Ounces. |
| Sulphuric acid | 2 " |

### Steel Color on Brass.

| | |
|---|---|
| Muriatic acid | 1 Quart. |
| Iron filings or chips | 1 Handful. |
| White arsenic | 1 Tablespoonful. |
| Water | 1 Gallon. |

Use hot.

## FORMULAS.

### Dark Brown Drab on Copper.

Sulpho Cyanide of potash. . . . . 2 Pennyweights,
Nitrate of iron. . . . . 5 "
Water. . . . . 1 Gallon.

**Red Copper Solution:**

Water. . . . . .75 Gallons.
Prepared red copper. . . . . .10 Pounds.
Cyanide of sodium. . . . . .10 "
Bisulphite of soda. . . . . .10 "

**Brass Solution:**

Water. . . . . 5 Gallons.
Sodium cyanide 96/98% . . . . . .14 Ounces.
Copper cyanide 70%. . . . . 7 Ounces.
Zinc cyanide . . . . . 3½ Ounces.
Soda ash . . . . . 4 Ounces.
Bisulphite of soda. . . . . 6 Ounces.
Small amount of ammonia and arsenic.

**Cyanide Copper Solution:**

Carbonate of copper. . . . . 5 Ounces.
Bisulphite of soda. . . . . 2 "
Cyanide of potassium. . . . . .10 "
Water. . . . . 1 Gallon.

**Royal Copper:**

Red lead . . . . . 1 Pound.
Banner lye . . . . . 2 "

Boil above 20 minutes in 1 gallon of water and add it to 10 gallons of water. Use copper anode. Rinse and heat until work becomes a cherry red, and develop color by buffing. Use a hard metal, copper preferred.

## FORMULAS.

**Tin Solution:**

| | |
|---|---|
| Muriate of tin | 6 Ounces. |
| Phosphate of soda | 6 " |
| Acetic acid | 2 " |
| Water | 1 Gallon. |

Use pure tin anode and low voltage. Acetic acid hardens deposit.

**Galvanizing Solution:**

| | |
|---|---|
| Water | 1 Gallon. |
| Sulphate of zinc | 2 Pounds. |
| " " aluminum | 1½ Ounces. |

Zinc anodes.

**Strip for Brass, Copper or German Silver:**

| | |
|---|---|
| Oil of vitriol | 5 Gallons. |
| Nitric acid | 10 Ounces. |

Use hot and remove work as soon as stripped. When acid is saturated, dilute six times its volume with water, and precipitate with salt water.

**Gold Precipitate:**

After cutting gold with aqua regia, precipitate with aqua ammonia, (aqua regia is)

| | |
|---|---|
| Nitric acid | 1 part. |
| Muriatic acid | 3 " |

**To Dissolve Arsenic:**

Arsenic can be dissolved in small quantities in the following alkalies and acids, readily if hot, and slowly if cold:

| | |
|---|---|
| Nitric acid | Ammonia |
| Sulphuric acid | Cyanide of potassium |
| Acetic acid | Caustic potash |
| Muriatic acid, Etc. | Carbonate of soda, |

Banner lye, etc.

## FORMULAS.

**Hydrosulphuret of Potash:**

Caustic potash. . . . . 8 Ounces.
Pulverized sulphur. . . . . 16 "
Water. . . . . 1 Quart.

Boil one hour. After cooling, filter and use the clear liquid only. Add warm water, as it boils away. It will turn a deep red color.

**Quick Electrotype:**

Fine copper bronze powder. . . . . 1 Ounce.
Plumbago. . . . . 1 "

Rub above mixture on cast until a fine surface is presented, and plate in acid copper solution.

**Bright Pickle for Iron:**

Water. . . . . 1 Gallon.
Sulphuric acid. . . . . 12 Ounces.
Zinc. . . . . 1 Ounce.
Nitric acid. . . . . 5 Ounces.

**Black Nickel Solution:**

Take (10) gallons of regular nickel solution (double sulphate of nickel and ammonia) standing 6° Bé, and add (1) pound sulphocyanide of potassium and half a pound (½ lb.) C. P. sulphate of zinc. Use old anodes and a current of about ¾ volts. Have the solution decidedly alkaline with ammonia. The zinc sulphate can be precipitated with sal-soda and washed thoroughly, then dissolved in strong ammonia. The latter method will make the solution sufficiently alkaline. A small amount of aluminum sulphate added to this solution will improve it.

## FORMULAS.

**Gold Strip:**

Sulphuric acid C. P..... 1 Pound.
Hydrochloric acid C. P..... 2-2/3 Ounces.
Nitric acid 40° Bé..... 1¼ Ounces.
Keep free from water.

**Soldering Acid:**

Cut zinc with muriatic acid to saturation, and evaporate to 1/3 by boiling, and allow to cool, and then add an equal volume of saturated sal-ammoniac solution, and add about 10% crude glycerine. The boiling prevents sputtering when using. The glycerine prevents discoloration of work.

**Green Gold Solution:**

Water..... 1 Gallon.
Gold as fulminate..... 4 Pennyweights.
Nitrate of silver..... 1 Pennyweight.
Cyanide..... 1 Ounce.

**Blue Oxidize on any Metal:**

Nitrate of lead..... 4 Ounces.
Nitrate of iron..... 2 Ounces.
Hyposulphite of soda.....16 Ounces.
Water..... 5 Gallons.
Use hot.

**Blue Color on Steel:**

Heat steel to straw color and plunge into common machine oil. The work will take on a beautiful blue color.

**Flux for Melting Silver:**

Bicarbonate of soda..... 1 Pound.
Cream of tartar..... 1¼ "
Silver..... 1 "

## FORMULAS.

**Dip Gold Solution:**

| | |
|---|---|
| Water | 1 Gallon. |
| Yellow prussiate of potash | 12 Ounces. |
| Phosphate of soda | 10 Ounces. |
| Sesquichloride of iron | 2 Ounces. |
| Fulminate of gold | 5 Pennyweights. |

Solution must be kept in iron kettle and boiling when in use.

**Verde Green Solution:**

| | |
|---|---|
| Water | 3 Quarts. |
| Chloride of calcium | 4 Ounces. |
| Chloride of ammonia | 4 Ounces. |
| Nitrate of copper | 4 Ounces. |

Brush on work and stipple.

**Acid Dip for Mat Finish on Brass:**

| | |
|---|---|
| Nitric acid | 1 Part. |
| Oil of vitriol | 2 Parts. |

Add Sulphate of zinc to full saturation. If mat finish is too coarse, add more oil of vitriol; if too fine, add nitric. Use hot and keep water out of dip as much as possible.

**Olive Green on Brass:**

| | |
|---|---|
| Acetate of copper | 5 Ounces. |
| Sulphate of copper | 2 Ounces. |
| Acetic Acid | 2 Ounces. |
| Water | 1 Gallon. |

Use solution hot.

1st. Brush work with a little pumice in water.

2nd. Cold water rinse.

## FORMULAS.

3rd. Place in coloring solution for 2 to 3 minutes.
4th. Cold water rinse.
5th. Dry and lacquer.
If not the shade desired, repeat.

**Electro Green Solution:**

*Plate on any Metal.*

| | | |
|---|---|---|
| Sulphate of nickel (single nickel salts) | 1½ | Pounds. |
| Sulphate of copper | ¾ | Pounds. |
| Potassium bichromate | 2 | Ounces. |
| Water | 1 | Gallon. |

Carbon or brass anodes.
Use a current at 12 to 15 Volts.

A very fine hard deposit of green is obtained.

**Electro Green for Relieving:**

| | | |
|---|---|---|
| Sulphate of nickel and ammonia (double nickel salts) | 1½ | Pounds. |
| Sulphate of copper | ¾ | Pounds. |
| Potassium bichromate | 2 | Ounces. |
| Water | 1 | Gallon. |

Carbon or brass Anodes.
Use 12 to 15 volts pressure.

**Fine Brown Bronze on Copper:**

| | | |
|---|---|---|
| Nickel-ammonium sulphate (Double nickel salts) | 12 | Ounces. |
| Copper sulphate | 2 | Ounces. |
| Water | 2 | Gallons. |

Use hot. Dip work in solution two or three minutes, take out, rinse in clean water, scratch brush with dry brush. If not the color desired, repeat as before.

## FORMULAS.

**Brown on Copper:**

Acetate of copper..... 5 Pounds.
Nitrate of copper..... 5 Pounds.
Salamoniac..... 1 Pound.
Water.....10 Gallons.

Use hot.

1st. Place in solution from 1 to 2 minutes.
2nd. Cold water rinse.
3rd. Scratch brush with a little pumice in water.
4th. Place in solution again for 1 to 2 minutes.
5th. Cold water rinse.
6th. Dry and lacquer.

**Light Brown on Copper:**

Water..... 1 Gallon.
Sulphate of copper..... 1 Pound.

Add caustic potash until solution turns black, then bring back to dark green with sulphate of copper. Use solution hot.

1st. Plate work in copper solution.
2nd. Rinse in cold water.
3rd. Place in coloring solution.
4th. Cold water rinse.
5th. Scratch brush with a little pumice in water.
6th. Dip in O. P. C. solution.
7th. Rinse in cold water.
8th. Place in coloring solution until the desired shade is obtained.
9th. Cold water rinse.
10th. Dry and lacquer.

## FORMULAS.

**Yellow Brown on Copper:**

Sulphate of copper..... 1 Pound.
Chlorate of potassium..... 4 Ounces.
Water..... 1 Gallon.
Use solution hot.

1st. Plate work in acid copper.
2nd. Cold water rinse.
3rd. Place in coloring solution for 2 minutes.
4th. Cold water rinse.
5th. Scratch brush with a little pumice in water.
6th. Dip in O. P. C. solution.
7th. Cold water rinse.
8th. Place in coloring solution until desired shade is obtained.
9th. Cold water rinse.
10th. Dry and lacquer.

**Barbadienne Bronze:**

First, plate object brass, then black nickel.

Second, put on a mixture of sanguine and black lead, equal parts, and enough gum arabic to make it stick, say about a wineglass full of gum arabic to a pint of water, and enough of water to make a very thin mixture.

Third, take equal parts of sanguine and pale gold bronze, mix very fine by grinding. If that does not give the desired shade add more of either color and nothing else. Use good varnish relief as for any bronze.

## FORMULAS.

**Flux to Clear Chloride of Silver of Chlorine:**

Add to chloride of silver in crucible before melting, 40% of calcined soda. Calcined soda is made by heating sal-soda on a hot surface until it is dry, and in a fine powdery form.

**To Crystallize Tin:**

Bring the tin article to a straw color by heating with blow pipe, and at once spray with cool water, and then plunge it into dilute sulphuric acid, which will bring out the crystals.

**A Simple Method for Testing Silver Solution for Silver:**

Take 4 ounces of silver solution to be tested, and precipitate with hydrochloric acid. If copper be present, it can be cut out easily with nitric acid. The nitric will not cut the silver. After the silver has gone to the bottom, draw off the fluid and place a small piece of zinc in the silver, which will with the acid or a few drops of sulphuric acid, drive out all chlorine and cyanogen, leaving it a dark colored pure silver which must be dried and weighed, which will give the true amount of silver per gallon of solution by multiplying by 32 the amount of silver found in 4 ounces of solution. As there are 128 ounces to a gallon, and we take 4 ounces of solution, so we multiply by 32 which gives the number of ounces per gallon.

*Note*: This method with proper manipulation will give pretty near perfect results.

## FORMULAS.

**To detect Iron in Sulphate of Copper:**

Dissolve sulphate of copper with ammonia to excess, which will redissolve the copper, and if iron be present it will remain at the bottom as hydrate of iron.

**Paint for Sectional Gold:**

Take gumguac and break with a hammer until it is in powder form, and then dissolve in wood alcohol and let stand 24 hours. Then strain through cheese cloth, and add any desired aniline color. Remove with lye or potash.

Another very good stop-off is

Collodion. . . . . 1 Part.
Lacquer. . . . . 1 Part.

Remove with lacquer thinner.

**Terra Cotta Bronze:**

Red sulphide of arsenic. . . . . ¾ Ounce.
Pearl ash. . . . . 6 Ounces.
Water. . . . . 1 Gallon.
Sulphuret of potash. . . . . 3 Pennyweights.

Use boiling hot.

**Jet Black on Copper:**

Water. . . . . 3 Gallons.
Pulverized sulphur . . . . . 9 Ounces.
Caustic potash . . . . . 1 Pound.

Boil until sulphur is all dissolved, then filter and add to 20 gallons of water. Use cold on copper, and scratch brush work before immersion. Finish on soft rag wheel with kerosene and rouge.

## FORMULAS.

**Silver Solder:**

Sterling silver. . . . . 40 Parts.
Brass. . . . . 30½ "

**Bronze Solution:**

Water. . . . . 1 Gallon.
Cyanide of potassium. . . . . 6 Ounces.
Bisulphite of soda. . . . . 2 Ounces.
Carbonate of copper. . . . . 4 Ounces.
Chloride of tin. . . . . ½ Ounce.
Use bronze anodes.

**Black Nickel Solution:**

Water. . . . . 1 Gallon.
Nickel-ammonium sulphate (Double nickel salts). . . . . 12 Ounces.
Sulpho cyan potash. . . . . 3 Ounces.
Carbonate of copper. . . . . 2 Ounces.
White arsenic. . . . . 2 Ounces.

**Dip Silver Solution:**

Water. . . . . 1 Gallon.
Cyanide of potassium. . . . . 2 Pounds.
Caustic potash. . . . . ½ Pound.
Chloride of silver. . . . . 1 Ounce.
Stir well and use hot.

**Royal Copper Solution:**

Red lead. . . . . ½ Pound.
Caustic stick potash. . . . . ½ Pound.
Water. . . . . 5 Gallons.
Use pure lead anodes.

*Note*: Copper plate work and then run in above solution for a couple of minutes, and then heat with blow-pipe flame and buff with red rouge.

## FORMULAS.

**Black Nickel Smut for French Grey:**

| | |
|---|---|
| Oxide of nickel | 5 Pounds. |
| Carbonate of copper | 1 Pound. |
| Sal-soda | 100 Pounds. |
| Water | 150 Gallons. |
| Carbonate of ammonia | 5 Pounds. |

Dissolve the copper and nickel in the ammonia.

**Verde Antique Paint.**

Chrome green,
" yellow,
Zinc white.

A very little yellow ocher. Mixed to desired consistency with turpentine.

**Dip Black on Brass:**

| | |
|---|---|
| Water | 1 Gallon. |
| Carbonate of soda | 4 Ounces. |
| Carbonate of Copper | 1 Pound. |
| Ammonia | 1 Quart. |

Use hot or cold.

**Crystallized Tin:**

Dip tin goods in a hot solution of water and sesquichloride of iron.

**To Separate Silver Metal from Copper:**

Cut the combination metals with nitric acid, and then precipitate with hydrochloric acid, which will throw the silver to the bottom as chloride, and hold the copper in the solution as chloride.

**To Recover Gold from an Old Solution:**

Place a quantity of scrap turnings or filings of zinc in the solution which will collect all the gold, after which draw off the solution, and

## FORMULAS.

then cut the zinc with hydrochloric acid, leaving the gold at the bottom.

*Note*: Cyanide of silver is not soluble in nitric acid unless heated. Cyanide of copper is soluble in nitric acid cold or hot.

**To remove fire stain from Sterling Silver:**

| | |
|---|---|
| Nitric acid | 1 Part. |
| Water | 1 " |

Use hot.

**To strip Silver from Steel:**

| | |
|---|---|
| Water | 1 Gallon. |
| Cyanide of sodium | 8 Ounces. |
| Chloride of silver | ½ Ounce. |

Use reverse current.

**Stop-Off or Paint for Etching:**

Virgin rubber dissolved with benzine. Add a small amount, say ¼ ounce of asphaltum to a tablespoonful of virgin rubber. Cut the asphaltum with turpentine, and add the rubber when dissolved to the asphaltum. This is strictly acid proof.

**Color Mixing Paints, Inks, etc.**

Red and black make brown,
Lake and white make rose,
White and brown make chestnut,
White, blue and lake make purple,
Blue and lead color make pearl,
White and carmine make pink,
Indigo and lamp black make silver gray,
White and lamp black make lead color,
Black and venetian red make chocolate,
Purple and white make French white,

## FORMULAS

Light green and black make dark green,
White and green make pea green,
White and emerald green make brilliant green,
Red and yellow make orange,
White, lake and vermillion make flesh color,
Umber, white and venetian make drab,
White, yellow and venetian red make cream,
Blue, black and red make olive,
Yellow, white and a little venetian red make buff,
White and green make bright green.
White, blue and grey make pearl grey.

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## ACID COPPER PLATING SOLUTION.

**Standard Formula:**

Water ..... 1 Gal. (U.S.)
Crystallized copper sulphate.....32 Ounces.

**Copper Determination:**

Put 5 c.c. of the solution using a pipette, into a 250 c.c. beaker. Add about 100 c.c. water and 25 c.c. conc. sulphuric acid. Cut off a small strip (about 1½ inches square) of aluminum foil and place it in beaker. Heat gently and the copper will be precipitated out as metallic copper. When solution becomes white, the copper can be filtered off using glass wool in funnel in place of filter paper. The filtrate is tested for copper by passing in $H_2S$ gas, which gives a black precipitate of copper sulphide if it is present, indicating that it was not

all precipitated by the aluminum foil. Wash the copper on the funnel once with hot water, then dissolve off the copper from the aluminum foil with warm conc. nitric acid pouring into funnel and receiving the dissolved copper in an Erlenmeyer flask. When all the copper is dissolved, the solution is heated until all nitrous fumes are gone, then add ammonium hydrate in slight excess and evaporate until most of the free ammonia has disappeared. Acetic acid is added in excess and heated. If solution is not clear it should not be heated too much as some of the copper will be lost by volatilization. When all the copper is in solution cool and add ten grams potassium iodide, making sure that all of it is dissolved before beginning titration. The free iodine that is liberated in the reaction is titrated with standard sodium thiosulphate solution, using starch as an indicator. The reaction between the copper acetate and potassium iodide is the formation of copper iodide and the liberation of iodine.

When the potassium iodide is added a yellow precipitate of cuprous iodide ($Cu_2 I_2$) is thrown down. The starch is not added until towards the end of the titration. It produces a lilac color and the potassium thiosulphate solution is added slowly until one or two drops shows a change to a cream which remains permanent and is not changed by the addition of more sodium thiosulphate solution.

**Calculation:**

Multiply the number of c.c. of sodium thiosulphate used by the copper sulphate (Cu S $O_4$5 H20) value for 1 c.c., then divide by 5. The result is multiplied by 133.54 which gives ounces (av.) of copper sulphate per gallon (U. S.)

The following example will illustrate it:

Used 61.0 c.c. sodium thiosulphate solution, the copper sulphate value for 1 c.c. is .01964. This multiplied by 61 will equal 1.19804, then divided by 5 will equal .2396; multiply this by 133.54 will equal 32 ounces of copper sulphate (Cu S $O_4$) 5 $H_2O$) per gallon.

**Standard sodium thiosulphate:**

Dissolve 39.2 grams of C. P. sodium thiosulphate in water and dilute to two liters. This solution is quite stable. A slight decomposition might occur soon after making the solution due to carbon dioxide or oxygen in the water. The solution should be kept in a brown bottle as actinic light will decompose it. To standardize, take one gram of pure copper foil and dissolve in about 20 c.c. dilute nitric acid. When dissolved, dilute to 250 c.c. Then take out 50 c.c. with pipette (this is equivalent to .2 grams of copper) into an Erlenmeyer flask. Boil out nitrous fumes; then add ammonium hydrate in slight excess and evaporate until most of the free ammonia has disappeared. Acetic acid is added in excess and heated if solution is not clear. When all the copper is in solution, cool and add ten grams of potassium iodide. Then titrate with

the sodium thiosulphate solution. The end point obtained when standardizing should be remembered and be the same when titrating samples.

The number of c.c. of sodium thiosulphate used is divided into .2 grams, and the result will be the number of grams of copper per c.c., and this multiplied by 3.9283 will give the copper sulphate ($Cu\ S\ O_4\ 5\ H_2O$) value of 1 c.c. of the solution.

**Starch Solution:**

Mix 0.25 gram of potato starch with 10 c.c. cold water; then add to boiling water with constant stirring to make about 400 c.c. When cold, use about 1 c.c. for titrating. It decomposes very readily and should be prepared fresh every day. It produces an intense blue with iodine, and if brownish red indicates decomposition. The following are the reactions that occur:

Copper acetate reacts with potassium iodide liberating free iodine as follows:

$2\ Cu\ (C_2\ H_3\ O_2)_2 + 4K\ I = Cu_2\ I_2 + 4\ (K\ C_2\ H_3\ O_2) + 2\ I$

The free iodine colors the solution brown. The iodine reacts with the sodium thiosulphate forming sodium iodide and sodium tetrathionate.

$2\ Na_2\ S_2\ O_3 + 2\ I = 2\ Na\ I + Na_2\ S_4\ O_6.$

The blue compound that is formed when starch is mixed with iodine is of unknown composition. It behaves towards sodium thio-

sulphate exactly as free iodine, and the reaction occurs as in the above equation.

**Sulphuric Acid determination:**

Measure out 5 c.c. of the solution with pipette into a 400 c.c. beaker; add 100 c.c. water and about 1 drop of a 5% solution of methyl orange. The solution will be a bright red. Place beaker on a white surface. From a 50 c.c. burette add $\frac{N}{1}$ — sodium hydrate until solution in beaker becomes a golden yellow. This indicates the end point. The number of c.c. used of the $\frac{N}{1}$ — sodium hydrate is noted and calculated as follows:

The number of c.c. $\frac{N}{1}$ — sodium hydrate used is multiplied by the sulphuric acid value of 1 c.c. (exactly $\frac{N}{1}$ — Na O H will be .04904 grams) then divided by 5, and the result multiplied by 133.54 will give ounces (av.) of sulphuric acid (100% per gallon (U. S.).

**Example:**

Used 8.0 c.c. $\frac{N}{1}$ — Na O H. The sulphuric

acid value of 1 c.c. is .04904. Multiply this by 8 will give .39232 and divided by 5 will equal .07846; then multiply by 133.54 will give 10.48 ounces (av.) of sulphuric acid per gallon (U. S.)

**Standard — Sodium Hydrate:** $\frac{N}{1}$

Dissolve 80 grams C. P. sodium hydrate in water and dilute to two liters. Standardize with $\frac{N}{1}$ sulphuric acid, using methyl orange as an indicator.

1 c. c. exactly $\frac{N}{1}$ Na O H = .0400 grams Na O H

1 c. c. " " = .04904 grams $H_2$ S $O_4$.

The following reactions occur in titrating:

$H_2 S O_4 + 2 Na O H = Na_2 S O_4 + 2 H_2 O$

Methyl orange is changed by alkalies to a yellow and by acids to a pink red, therefore in titrating acidity it will indicate when sufficient sodium hydrate has been added, as an excess will change color to a yellow.

**Copper Determination:**

Put 10 c.c. of the solution with a pipette into a 250 c.c. beaker. Add 15 c.c. conc. H Cl. Care should be taken not to inhale the gas, as it is very poisonous. Boil a few minutes then add 5 c.c. $H_2 O_2$ and continue boiling for

fifteen minutes, adding water occasionally for the loss by evaporation. After decomposition of the cyanide 100 c.c. water are added and solution heated, then $H_2$ S gas passed in for about ten minutes to precipitate the copper as Cu S. After precipitation, place beaker on water bath until precipitate collects and falls to the bottom, then filter it off washing with $H_2$ S water three or four times. The filtrate is set aside for zinc determination. The filter paper containing the copper sulphide is removed from the funnel and the sulphide washed into a 250 c.c. beaker. The small portions that cannot be removed by washing can be dissolved by pouring on conc. nitric acid, adding sufficient finally to dissolve all of the Cu S. Boil out excess of H N $O_3$ and filter off any sulphur that has collected in small yellow lumps. Filter into an Erlenmeyer flask and neutralize with N $H_4$ O H, adding slight excess; then boil until N $H_4$ O H is faint. Add excess of acetic acid and boil for a couple of minutes until all the copper salts are in solution. Cool to the ordinary temperature (to prevent volatilizing free iodine) and add 10 grams of K I. The free iodine is titrated with standard sodium thiosulphate solution until the brown tinge has become faint, then add sufficient starch solution to produce a decided blue color. The titration is continued with vigorous shaking until a permanent cream

color is produced. The starch solution should be weak as otherwise it tends to occlude iodine forming very small lumps that are not readily acted on by the thiosulphate solution. About .25 gram in 400 c.c. of water is the correct strength to use.

## BRASS PLATING SOLUTION.

**Standard formula:**

| | | |
|---|---|---|
| Copper cyanide 70% | 8½ | Ounces. |
| Zinc cyanide 55% | 4½ | Ounces. |
| Sodium cyanide 96/98% | 16 | Ounces. |
| Water | 1 | Gallon. |

**Calculation:**

Multiply the number of c.c. of sodium thiosulphate used by the copper value for 1 c.c. Then divide by 10. The result multiplied by 133.54 with equal ounces (av.) of copper per gallon. To convert this to copper carbonate, multiply by 1.8812. This will give copper carbonate as figured from its theoretical formula ($Cu\ C\ O_3\ Cu\ (OH)_2\ H_2\ O$). The formula differs according to the method of manufacturing the copper carbonate. A true basic copper carbonate having the above formula would analyze as follows:

| | | |
|---|---|---|
| Cupric oxide | ($Cu\ O$) | 66.54 |
| Carbon dioxide | ($CO_2$) | 18.40 |
| Water | ($H_2O$) | 15.06 |
| | | 100.00 |

**Sodium Thiosulphate:**

Use the same solution as is used for acid copper. The copper carbonate ($Cu\ C\ O_3\ Cu\ (OH)_2\ H_2O$.

Value for 1 c.c. is found by multiplying the copper value by 1.8812 or to find any other value multiply by the following factors:

$Cu \times 1.2517 = Cu\ O$
$Cu\ O \times 0.7989 = Cu$
$Cu \times 1.8812 = Cu\ C\ O_3\ Cu\ (OH)_2\ H_2O$

**Zinc Determination:**

The filtrate from the Copper Sulphide is boiled to expel $H_2S$, then neutralized with $N\ H_4\ O\ H$. Add 10 c.c. conc. H Cl and 5 grams of ammonium chloride and dilute to 250 c.c. Heat solution nearly to boiling, then take out a portion, about 50 c.c. into another beaker; run into the remaining portion with vigorous stirring standard potassium ferrocyanide solution until a brown tinge is produced, when a few drops are taken out on a porcelain plate and mixed with a solution of uranium acetate. The portion that was taken into the beaker is then added in small portions at a time continuing the titration after each portion is added. After the addition of the last portion the ferrocyanide solution is added by drops until the end point is obtained as a brown color with the uranium acetate. A correction for the reaction with the indicator, having the same conditions as

above — that is, volume, temperature, ammonium chloride and free acid, but without the zinc — is determined. This correction, which will not amount to more than a few tenths of a c.c., is always subtracted from the burette reading when a titration is made.

**Calculation:**

Multiply the number of c.c. of potassium ferrocyanide solution used by the zinc value for 1 c.c. then divide by 10. The result multiplied by 133.54 will equal ounces of zinc per gallon. To convert this to zinc carbonate: ($5\ Zn\ O.\ 2\ C\ O_2\ 4\ H_2O$), multiply by 1.7345.

Basic zinc carbonates differ in composition like the copper carbonate according to the method of manufacture. The true basic zinc carbonate has the above formula and would test as follows:

| | | |
|---|---|---|
| Zinc oxide | ($Z\ N\ O$) | 71.77% |
| Carbon dioxide | ($C\ \ O_2$) | 15.52% |
| Water | ($H\ \ O_2$) | 12.71% |
| | | 100.00% |

**Potassium Ferrocyanide:**

48.6675 grams of Merck's pure potassium ferrocyanide are dissolved in water and made up to 2250 c.c. and kept in a brown bottle.

**Uranium Acetate:**

Dissolve 4.4 grams of Merck's salt in 100 c.c. of water and 2 c.c. of acetic acid.

Standardizing the potassium ferrocyanide solution:

0.3 grams of Merck's pure zinc are dissolved in 25 c.c. of dilute H Cl (1 part H Cl, 3 parts $H_2O$), then add 4 grams of pure N $H_4$ Cl and dilute to 250 c.c. with water and heat almost to the boiling point. Then run in about 58 c.c. of the potassium ferrocyanide solution, stirring vigorously. Take out two or three drops on a plate covered with paraffine and mix with a drop or two of the uranium acetate solution. Continue the titration until the first faint tinge of brown red color. Another portion of 0.3 grams of zinc is also titrated and should agree with the first portion within 0.1 c.c. A correction for the reaction, having the same volume of $H_2O$, H Cl, and same number of grams of N $H_4$ Cl but without the zinc, is determined. This correction is deducted from the number of c.c. used in titrating the 0.3 grams sample.

To find the value of 1 c.c. of potassium ferrocyanide solution in terms of zinc, divide 0.3 by the corrected c.c. of the ferrocyanide used and the result will be the grams of zinc in 1 c.c. of the potassium ferrocyanide solution. To find the value in terms of zinc oxide or carbonate, multiply the zinc value by the following factors:

Zn $\times$ 1.2448 = Zn O
Zn O $\times$ 0.8034 = Zn
Zn $\times$ 1.7345 = 5 Zn O. 2 C $O_2$. 4 $H_2O$

The reactions that occur in titrating between zinc chloride and potassium ferrocyanide vary according to temperature, quantity of solution, and amount of acid.

The probable reactions, using the above methods, are as follows:

$$4\ Zn\ Cl_2 + 2\ K_4\ Fe\ (C\ N)_6 = 8\ K\ Cl + 2\ Zn_2\ Fe\ C\ N_6$$

A secondary reaction then takes place:

$$6\ Zn_2\ Fe\ (C\ N)_6 + 2\ K_4\ Fe\ (C\ N)_6 = 4\ K_2\ Zn_3\ (Fe\ (C\ N)_6\ )_2.$$

## RESULTS OBTAINED BY ANALYSIS OF BRASS SOLUTION.

In making up a brass solution, put in the metal at the rate of 5 parts carbonate of copper, and 3 parts carbonate of zinc. One would naturally think when a test was made of this solution that the same proportion of copper and zinc would be found, but I find that when an analysis is made the proportions are quite different, as there is always a sediment in the bottom of a brass solution, and this sediment in my experience is mostly zinc, with a very small amount of copper. So do not run away with the idea of being able to test your solution and get the same amount as you weighed and put in, as it seems to be impossible to make a brass solution and take up all the metal. For instance try and make up a standard brass solution, and that will show you that it is next to impossible to take up all the

metal. I find the best way is to take a small amount of solution from the top of one of the tanks which is clear, and then standardize it by analysis, which will prove to you the true amount of metal in the solution.

For example, make up a solution of

12 Ounces copper carbonate,
6 Ounces zinc carbonate.

and then you say to yourself, I have a solution with the above named amounts in it. You are wrong, as a good part of the compound is lying on the bottom of the tank, and is not in solution.

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## CYANIDE COPPER PLATING SOLUTION.

**Copper Determination:**

Take 10 c.c. of the solution with a pipette into a 250 c.c. beaker. Add 15 c.c. conc. H Cl. Care should be taken not to inhale the gas, as it is very poisonous. Boil a few minutes, then add 5 c.c. $H_2O_2$ and continue boiling for fifteen minutes, adding water occasionally for the loss by evaporation. After decomposition of the cyanide 100 c.c. of water is added and solution heated, then $H_2S$ gas passed in for about ten minutes to precipitate the copper as Cu S. After precipitation place beaker on water bath until precipitate collects and falls to the bottom, then filter it off washing with $H_2S$ water three or four times. The filter

paper containing the copper sulphide is removed from the funnel and the sulphide washed into a 250 c.c. beaker. The small portions that cannot be removed by washing can be dissolved by pouring conc. nitric acid adding sufficient finally to dissolve all of the Cu S. Boil out excess of $H N O_3$ and filter off any sulphur that has collected in small yellow lumps. Filter into an Erlenmeyer flask and neutralize with $N H_4 O H$, adding slight excess; then boil until $N H_4 O H$ is faint. Add excess of acetic acid and boil for a couple of minutes until all the copper salts are in solution. Cool to the ordinary temperature (to prevent volatilizing free iodine) and add 10 grams of K I. The free iodine is titrated with standard sodium thiosulphate solution until the brown tinge has become faint, then add sufficient starch solution to produce a decided blue color. The titration is continued with vigorous shaking until a permanent cream color is produced. The starch solution should be weak, as otherwise it tends to occlude iodine, forming very small lumps that are not readily acted on by the thiosulphate solution. About .25 gram in 400 c.c. of water is the correct strength to use.

**Calculation:**

Multiply the number of c.c. of sodium thiosulphate used by the copper value for 1 c.c. Then divide by 10. The result multiplied by 133.54 will equal ounces (av.) of copper per

gallon. To convert this to copper carbonate multiply by 1.8812. This will give copper carbonate as figured from its theoretical formula ($Cu\ C\ O_3\ Cu\ (OH)_2\ H_2O$). The formula differs according to the method of manufacturing the copper carbonate. A true basic copper carbonate having the above formula would analyze as follows:

| | | |
|---|---|---|
| Cupric oxide | ($Cu\ O$) | 66.54 |
| Carbon dioxide | ($C\ O_2$) | 18.40 |
| Water | ($H_2O$) | 15.06 |
| | | 100.00 |

**Standard Solutions:**

**Sodium Thiosulphate:**

Use the same solution as is used for acid copper. The copper carbonate ($Cu\ C\ O_3\ Cu\ (O\ H)_2\ H_2O$

Value for 1 c.c. is found by multiplying the copper value by 1.8812, or to find any other value multiply by the following factors:

$Cu \times 1.2517 = Cu\ O$
$Cu\ O \times 0.7989 = Cu$
$Cu \times 1.8812 = Cu\ C\ O_3\ Cu\ (OH)_2\ H_2O$

## ASSAY TEST OF GOLD IN GOLD PLATING SOLUTIONS.

**Apparatus Necessary:**

Evaporating Dish,
Crucible,
Gas furnace,
Cupel mould,

Balance,
100 c. c. Graduated flask.

**Chemicals:**

Sodium bicarbonate,
Lead oxide,
Argol,
Bone ash.

75 c.c. of the solution is taken and evaporated to dryness in an evaporating dish. The residue is scraped off and put in a crucible (any good sand or clay crucible about 4½ inches in height will do) with the following charge:

20 grams Na H C $O_3$ (Sodium bicarbonate)
70 " Pb O (Lead oxide)
3 " Argol (Cream of tartar)

The whole is now thoroughly mixed in the crucible. It is now ready for the furnace. The heat is applied slowly at first, gradually increasing till the flux melts. The flux has action and appears to boil mildly. The crucible is left in the furnace about 25 minutes, being occasionally swirled and should not be removed until all action in the crucible has ceased.

It is now taken out, swirled and allowed to cool. When cool the crucible is broken open and a lead button is found in the bottom. This button contains the gold and should be freed from any particles clinging to it by hammering.

A bone ash cupel is now moulded and baked. Cupels are made of bone ash slightly moistened with water so that the powder will cling

together. The mixture should be well kneaded before being put in the cupel mould. On coming out of the mould it is slowly baked in the furnace and if possible the cupel should be air dried for a week or so although this is not essential.

The lead button is now put in the cupel and is ready for the furnace. A high heat is maintained for a few minutes in order that the lead may melt quickly and oxidation commence as soon as possible. After the fumes of lead oxide are observed to rise from the surface of the cupel, the heat is moderated and as free a flow of air as possible is given. The lead is lost in the air as lead oxide, and a great deal is absorbed by the cupel. When all the lead is gone the bead loses all lustre. The change of color is readily noticed and the cupel is withdrawn from the furnace with its small bead of gold.

The gold is weighed and the pennyweights per gallon may be calculated as follows:

Weight gold $\times$ 50.33 = number of grams per gallon.

Grams per gallon of solution.

Grams per gallon $\div$ 1.55 = pennyweight per gallon.

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## NICKEL PLATING SOLUTION:

**Standard Formula:**

Nickel ammonium sulphate (Double nickel salts).....12 Ounces.
Water..... 1 Gallon.

**Nickel Determination:**

Measure out 25 c.c. of the solution with pipette into a 250 c.c. beaker. Add about 2 c.c. Conc. sulphuric acid and heat almost to the boiling point. Pass in hydrogen sulphide gas to precipitate any metals such as copper, antimony, tin. If present, the precipitate is filtered off, washing with $H_2S$ water, and after washing thoroughly the filtrate is boiled to expel $H_2S$. When entirely free from $H_2S$ the iron is oxidized with 5 c.c. of hydrogen peroxide and boiled until the hydrogen peroxide is decomposed (takes about 15 to 20 minutes).

The iron found in nickel salts is an impurity and should be present only as a trace. After boiling about twenty minutes the iron is precipitated with ammonium hydrate filtered and washed once or twice with hot water. The precipitate is dissolved in dilute sulphuric acid (1 part sulphuric acid and three parts water); it is then reprecipitated with ammonium hydrate; the second filtrate is then added to the first. This second precipitation is necessary with large amounts of iron, as the iron occludes some of the nickel when it is precipitated.

The filtrate is transferred to a 500 c.c. beaker, boiled to expel free ammonia and neutralized with sulphuric acid, using litmus paper as an indicator. When solution is neutral add 2 c.c. Conc. ammonium hydrate and dilute solution to 250 c.c. with water; then

cool to 68°F. It is now ready to be titrated with standard potassium cyanide solution as follows: Run into the solution from a 50 c.c. burette 5 c.c. of standard silver nitrate solution (prepared according to directions under standard solutions). Add 0.5 c.c. of a 2% solution of potassium iodide which throws down a precipitate of silver iodide. This precipitate is used as an indicator to show when all of the nickel has combined with the potassium cyanide solution as an excess of potassium cyanide will dissolve it. The beaker containing the solution is placed on a black surface and standard potassium cyanide solution is run in slowly from a 50 c.c. burette until the disappearance of the precipitate of silver iodide. This indicates the end point, but usually an excess of potassium cyanide is used to dissolve the silver iodide, then this excess can be found by running in the silver nitrate until the first appearance of a precipitate; then one or two drops of the potassium cyanide solution should give a very clear solution. The number of c.c. of silver nitrate and potassium cyanide used is read off and amount of nickel ammonium sulphate calculated as follows:

The c.c. of silver nitrate used is converted into equivalent c.c. of potassium cyanide by a factor found under silver nitrate solution. After multiplying by this factor the c.c. obtained are subtracted from c.c. of potassium cyanide used, and the result will be the cor-

rect number of c.c. of potassium cyanide used for titrating sample. The nickel ammonium sulphate value of 1 c.c. of the potassium cyanide solution (see potassium cyanide solution for this value) is multiplied by the c.c. of potassium cyanide used, and divided by 25 c.c., then the result multiplied by 133.54 will give the ounces (av.) of nickel ammonium sulphate.

($Ni\ S\ O_4\ (N\ H_4)_2\ S\ O_4 + 6H_2O$) per gallon (U. S.)

The following example will illustrate it:

The factor to convert c.c. of silver nitrate to equivalent c.c. of potassium cyanide was found to be 0.2. Used 30.4 c.c. of silver nitrate, and multiplying by 0.2 will equal 6.08 c.c. potassium cyanide. Run into the solution 74.88 c.c. of potassium cyanide, then subtracting 6.08 will leave 68.8 c.c. of potassium cyanide actually used.

The value of 1 c.c. of potassium cyanide solution in grams of nickel-ammonium sulphate was found to be .03265, which multiplied by 68.8 c.c. will give 2.24632, and divided by 25 c.c. will equal .0898, then multiplied by 133.54 will give 12 ounces of nickel-ammonium sulphate per gallon.

**Standard Silver Nitrate Solution:**

Dissolve 11.6 grams of C. P. silver nitrate in water and dilute to two liters. This solution is to be kept in a brown bottle, as the light will decompose it. To find the factor to give

equivalent c.c. of potassium cyanide solution, take 15 c.c. of the silver nitrate, add 2 c.c. Conc. ammonia and dilute with water to 250 c.c. Add 0.5 c.c. of potassium iodide and run in potassium cyanide solution slowly until disappearance of precipitate. The number of c.c. used is divided by 15 c.c., and the result will be the factor to convert c.c. of silver nitrate to c.c. of potassium cyanide.

**Standard Potassium Cyanide Solution:**

Dissolve 44.5 grams of C. P. potassium cyanide (Merck's Reagent) in water and dilute to two liters. Solution should be kept in a brown bottle and will have to be standardized every few days as it does not remain stable.

Standardize as follows: Weigh 1 gram C. P. nickel (Electrolytic) and dissolve in 5 c.c. of dilute nitric acid and 10 c.c. of dilute sulphuric acid and a little water. When dissolved, transfer to a 250 c.c. graduated flask; cool, and dilute to 250 c.c. with water. Take out 50 c.c. with pipette which is equivalent to .2 grams of nickel. (50 c.c. is $\frac{1}{5}$ of 250 c.c. and $\frac{1}{5}$ of 1 gram is .2 gram). Neutralize with ammonia; then add 2 c.c. in excess, and titrate with the silver nitrate and potassium cyanide, as in the directions already given. The c.c. of potassium cyanide used is divided into .2 grams, and the result multiplied by 6.7314 will be the nickel-ammonium sulphate ($Ni\ S\ O_4\ (N\ H_4)_2\ S\ O_4$

$6H_2O$) value for 1 c.c. of the potassium cyanide solution.

The following are the reactions that occur:

Silver nitrate reacts with potassium iodide as follows:

$AgNO_3 + KI = AgI + KNO_3$

The reaction of nickel sulphate with potassium cyanide is as follows:

$NiSO_4 + 4KCN = (KCN)_2 Ni(CN)_2 + K_2SO_4$.

The silver iodide is dissolved by the potassium cyanide during titration forming the double salt potassium silver cyanide as in the following equation:

$AgI + 2KCN = KCN\,AgCN + KI$.

If cobalt is present it will be estimated with the nickel. Its presence is shown by the solution darkening.

## SILVER PLATING SOLUTION.

**Standard Formula:**

| | | |
|---|---|---|
| Silver Chloride | 4 | Ounces (av.) |
| Potassium Cyanide | 12 | " (av.) |
| Water | 1 | Gallon (U.S.) |

**Silver Determination:**

Measure out 25 c.c. of the solution with a 25 c.c. pipette into a 400 c.c. beaker, using a long rubber tube on pipette for aspirating the solution so as to prevent it being sucked into the mouth. Add 100 c.c. of water to the beaker and heat almost to the boiling point, then precipitate the silver as silver sulphide ($Ag_2S$) with hydrogen sulphide gas ($H_2S$). When

complete precipitation has taken place, filter off the silver sulphide on an E. and A. filter paper 13 cm., washing the precipitate with hydrogen sulphide water several times. The paper and precipitate is removed from the funnel, and the silver sulphide washed from the paper into a 250 c.c. beaker with water. (The adhering pieces on the paper can be removed with conc. nitric acid). The silver sulphide is dissolved in a small quantity of conc. nitric acid, then the solution is boiled to expel the nitrous fumes, as their presence will interfere with the titration. After boiling off the nitrous fumes the solution is cooled and diluted to about 150 c.c. with water and titrated as follows:

Add 5 c.c. of a cold saturated solution of iron alum (ferric ammonium sulphate). If the solution becomes turbid, nitric acid is added drop by drop until clear. Place the beaker on a white surface and add the standard $\frac{N}{10}$ — potassium sulphocyanate solution from a 50 c.c. burette with constant stirring until a faint permanent reddish tinge of ferric sulphocyanate — $Fe_2$ (S C N)$_6$ — is produced. The number of c.c. used is noted and the ounces of silver chloride per gallon calculated as follows:

Multiply the c.c. of $\frac{N}{10}$ potassium sulpho-

cyanate used by the silver chloride value for 1 $\frac{N}{10}$ c.c. (for exactly — it is .01433 grams), then divide by 25 (number of c.c. taken for analysis). This will give the grams of silver chloride in 1 c.c. of the plating solution. To convert this to ounces (av.) per gallon (U. S.), multiply by 133.54.

The following example will illustrate it: Used 52.3 c.c. $\frac{N}{10}$ — potassium sulphocyanate; multiply by .01433 will equal .74946, and divide by 25 will equal .02997 grams silver chloride in 1 c.c. of plating solution, then multiply by 133.54, and the result will be 4 ounces of silver chloride per gallon (U. S.)

**Standard $\frac{N}{10}$ — Potassium Sulphocyanate:**

Dissolve 20 grams of potassium sulphocyanate in water and dilute to two liters. Standardize it by taking 0.4 grams granulated silver (999 fine) in a 250 c.c. dilute nitric acid (equal parts of conc. nitric acid and water). After the silver is dissolved, the solution is boiled to expel nitrous fumes. When entirely free from nitrous fumes (this is shown by no more yellow fumes coming off) the solution is cooled and diluted to 150 c.c. with water; then add 5 c.c. of indicator (iron alum) and titrate with

the potassium sulphocyanate solution until the first permanent pink is produced. The number of c.c. used divided into 0.4 gram, will give the grams of silver in 1 c.c. of the solution, and this multiplied by 1.3287 will give the grams of silver chloride in 1 c.c. of the potassium sulphocyanate solution.

The following are the reactions that take place in titrating:

$$Ag\ N\ O_3 + K\ S\ C\ N = Ag\ S\ C\ N + K\ N\ O_3$$

An excess of potassium sulphocyanate then reacts with iron alum as follows:

$$2\ Fe\ N\ H_4\ (S\ O_4)_2 + 6\ K\ S\ C\ N = Fe_2\ (S\ C\ N)_6\ N\ H_4)_2\ S\ O_4 + 3\ K_2\ S\ O_4.$$

This method is accurate in the presence of copper (not exceeding 70%), arsenic, antimony, cadmium, lead, bismuth, tin, zinc, iron and manganese. Mercury if present will interfere, and therefore should be removed before titrating.

**Uncombined Cyanide determination:**

Take 10 c.c. of the plating solution into a 400 c.c. beaker; add about 100 c.c. water and 2 c.c. of Conc. ammonium hydrate and about 1 c.c. of 2% potassium iodide solution; then run in from a 50 c.c. burette $\frac{N}{10}$ silver nitrate until a permanent white precipitate of silver iodide is formed. This indicates the end point. The number of c.c. of silver nitrate used is

noted and calculated as follows:

$\frac{N}{10}$ c.c. — $Ag\ N\ O_3$ = .005202 gms. C. N. The number of c.c. $Ag\ N\ O_3$ used times .005202 — "x" grams C N in 10 c.c. of the plating solution. Then "x" grams C N divided by 10 will give the grams of C N in 1 c.c. of plating solution, which multiplied by 133.54 will be the ounces (av.) of C N per gallon (U. S.).

This determination is figured as C N, not as K C N, as the majority of the potassium cyanides on the market contain large quantities of Na C N which would be included when figuring the uncombined cyanide as K C N.

The uncombined cyanide is the K C N or Na C N that has not combined with the Ag Cl to form the double salt Ag C N K C N as in the equation:

$Ag\ Cl + 2K\ C\ N = Ag\ C\ N\ K\ C\ N + K\ Cl.$

In titrating the free K C N or Na C N with $Ag\ N\ O_3$ the double salt (Ag C N K C N) is not titrated by the $Ag\ N\ O_3$, only the free K C N or Na C N as in the following equations:

$Ag\ N\ O_3 + 2\ K\ C\ N = Ag\ C\ N\ K\ C\ N + K\ N\ O_3$

Then an excess of $Ag\ N\ O_3$ reacts with the Kl as follows:

$Ag\ N\ O_3 + K\ I = Ag\ I + K\ N\ O_3$

**Standard $\frac{N}{10}$ — Silver Nitrate Solution:**

Dissolve 33.978 grams of pure silver nitrate in water and dilute to two liters. To stand-

ardize take 0.25 grams C. P. sodium chloride (Merck's Reagent) in a 400 c.c. beaker; add 100 c.c. water, and when all of the salt has been dissolved add 1 c.c. of a 2% solution of neutral potassium chromate as an indicator.

Place beaker on a white surface and titrate with the silver solution from a burette until a faint red tinge is obtained. The end point is somewhat difficult to distinguish. The faint red tinge can be more distinctly seen if another beaker containing 150 c.c. water and 1 c.c. of the chromate solution is compared with it. The sodium chloride solution should be neutral or faintly alkaline and cold. The number of c.c. of silver nitrate solution used (exactly $\frac{N}{10}$ would take 42.76 c.c.) divided into 0.25 grams sodium chloride will give the number of grams of sodium chloride in 1 c.c. of the silver nitrate solution. The other values can be found by multiplying the sodium chloride value by the following factors:

Na Cl × 0.8898 = CN
" " 2.2275 = KCN
" " 1.6767 = NaCN

1 c.c. Exactly $\frac{N}{10}$ $AgNO_3$ = .005202 gms. CN

1 c.c. " $\frac{N}{10}$ $AgNO_3$ = .01302 " KCN

1 c.c. " $\frac{N}{10}$ $AgNO_3$ = .009802 " NaCN

1 c.c. " $\frac{N}{10}$ $AgNO_3$ = .005846 " NaCl

## CYANIDE DETERMINATION IN POTASSIUM CYANIDE.

Weigh off about 15 grams of the potassium cyanide in a tared weighing bottle, dissolve in water without heat and dilute to 500 c.c.

Take out 10 c.c. with pipette into a beaker, add 2 c.c. of Conc. N $H_4$ O H and 1 c.c. K I solution (2%) and about 100 c.c. water, then run in $\frac{N}{10}$ Ag N $O_3$ from a burette until a permanent white precipitate of silver iodide is formed. The number of c.c. of Ag N $O_3$ used multiplied by .005202 and divided by the weight taken, then multiplied by 100 = % CN in sample.

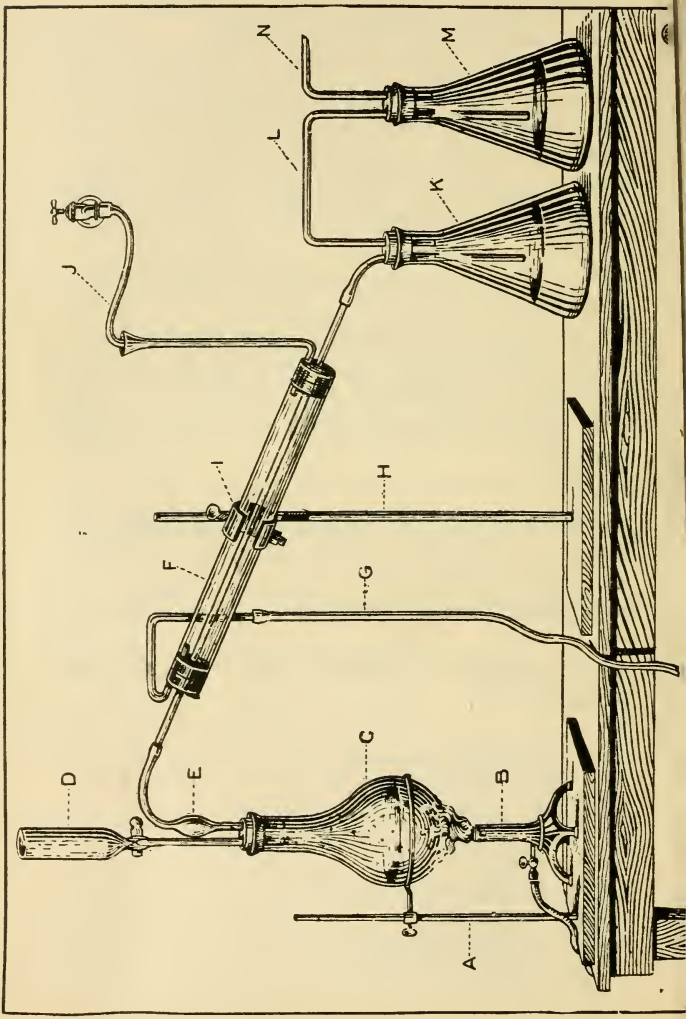
**Example:**

15.281 grams of potassium cyanide were dissolved and diluted to 500 c.c., then 10 c.c. (.3051 grams) required 23.45 c.c. $\frac{N}{10}$ Ag N $O_3$

23.45 × .005202=.121988 ÷ .3051=.3999×100 = 39.99% C N.

**Factors:**

CN × 1.8843 = NaCN
CN × 2.5033 = KCN
NaCN × 0.53071 = CN
KCN × 0.39947 = CN
Ag × 1.3287 = AgCl
Ag × 0.4822 = CN
AgCl × 0.36291 = CN
Ag × 0.90847 = KCN
Ag × 0.68382 = NaCN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## TOTAL POTASSIUM AND SODIUM CYANIDE DETERMINATION IN SILVER SOLUTION.

In an apparatus as shown in Fig. 16 distill 10 c.c. of silver solution to be tested for cyanide, potassium cyanide, or sodium cyanide, as follows:

Take 10 c.c. of silver solution, add 10 c.c. of water ($H_2O$), and place in Jena Kjeldahl Flask (C) connected with stop cock funnel (D) and connect with glass tube into Liebig Condenser (F). On receiving end of condenser have bottles (K & M) connected to collect steam. Place in funnel (D) 25 c.c. sulphuric acid ($H_2 S O_4$) and 25 c.c. water ($H_2 O$) and then place in bottle (K) at receiving end of condenser 50 c.c. water ($H_2 O$) and 1 gram of sodium hydrate (Na O H). Add the sulphuric acid and water that is in funnel (D) to the silver solution in Kjeldahl Flask (C) drop by drop while over flame (B). A slow stream of water must be kept running through the condenser (F) by connecting the lower rubber tube (J) with a water cock (O). When the solution is boiled in the Kjeldahl Flask (C) by means of a Bunsen burner flame (B) placed under flask, the steam passes into the inner tube of the condenser (F). As this is surrounded by cold water the steam condenses and the distilled cyanide solution collects in the receiver (K) at the other end of condenser. When all the cyanide has come over,

you will notice acid fumes in the flask. Then titrate the cyanide solution which has been collected in the receiver with $\frac{N}{10}$ silver nitrate solution ($Ag\ N\ O_3$).

Before titrating, take cyanide solution collected from condenser, and add 1 c.c. potassium iodide solution (K I) 2% solution, and about 100 c.c. water, then run in from a burette $\frac{N}{10}$ silver nitrate until a permanent white precipitate of silver iodide is formed. This indicates the end point. The number of c.c. of silver nitrate used is noted and calculated as follows:

1 c.c. $\frac{N}{10}$ $Ag\ N\ O_3 = .005202$ gms. C N. The number of c.c. $Ag\ N\ O_3$ used times $.005202 =$ "x" grams C N in 10 c.c. of the plating solution. Then "x" grams C N divided by 10 will give the grams of C N in 1 c.c. of plating solution, which multiplied by 3785 will be the grams cyanide per gallon. As there are 30 grams in one ounce, divide by 30 which will be ounces per gallon. As there is only about 39 to 40% cyanide in potassium cyanide, you multiply the amount of cyanide by 2.5, which will give you the amount of potassium cyanide per gallon in silver solution, minus 20% which is lost.

The 20% loss in the above method is due to the cyanide decomposing, etc., and about 7% of it turns into carbonate of potassium.

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## POTASSIUM CARBONATE IN SILVER SOLUTION.

In an apparatus as shown in Fig. 16 distill 5 c.c. of silver solution to be tested for potassium carbonate as follows:

Take 5 c.c. of silver solution, add 5 c.c. water, and place in Jena Kjeldahl flask connected with stop cock funnel, and connect with glass tube into Liebig Condenser. On receiving end of condenser have bottle connected to collect steam. Place in funnel 25 c.c. sulphuric acid ($H_2$ S $O_4$) and 25 c.c. water ($H_2$ O) and then place in bottle at receiving end of condenser 50 c.c. saturated solution of barium hydroxide and water. This is water that has taken into solution all the barium hydroxide that it will hold.

Add the sulphuric acid and water that is in funnel to silver solution drop by drop while over flame. A slow stream of water must be kept running through the condenser by connecting the lower rubber tube with a water cock. When the solution is boiled in the Kjeldahl flask by means of a bunsen burner flame placed under flask, the steam passes into the inner tube of the condenser. As this is surrounded by cold water the steam condenses and the potassium carbonate in the

solution is broken up and carbon dioxide ($C\ O_2$) is distilled over. The carbon dioxide combines with the barium hydroxide to form barium carbonate and water after the following equation:

$C\ O_2 + Ba\ (O\ H)_2 = Ba\ C\ O_3 + H_2\ O.$

The barium carbonate is a white precipitate.

When all is distilled over acid fumes will be seen in the flask, and the flame is taken away.

The barium carbonate is filtered off and heated in a weighed crucible.

When heated the barium carbonate is changed to barium oxide and is then weighed as such.

$Ba\ C\ O_3 = Ba\ O + C\ O_2.$

The barium oxide is figured to potassium carbonate in oz. per gal. as follows:

Wt. Ba O multiplied by .9 = Wt. $K_2\ C\ O_3$. Wt. $K_2\ C\ O_3 \div$ No. of c.c. taken. Then multiplied by 133.54 = no. ozs. of $K_2\ C\ O_3$ in 1 gallon of silver solution.

## CHEMICALS USED IN PLATING ROOM.

Sulphuric Acid,
Nitric Acid,
Muriatic Acid,
Citric Acid,
Boracic Acid,
Arsenious Acid,
Hydrofluoric Acid,
Bichromate of Potassium,
Caustic Potash or Potassium Hydrate,
Cyanide of Potassium,
" " Silver,
" " Copper,
" " Zinc,
Sodium Carbonate,
" Bicarbonate,
" Bisulphite,
" Hyposulphite,
" Nitrate,
" Phosphate,
" Chloride, or Common Salt,
Sodium Cyanide,
Barium Sulphide,
Ammonium "
Hydrosulphuret Ammonium,
Ammonium Chloride,
" Hydrate,
Yellow Prussiate of Potash, or
Potassium Ferrocyanide,
Sodium "
Barium "
Acetic Acid,
Ammonia,
Caustic Soda or Sodium Hydrate,
Potassium Sulphuret,
Copper Chloride,
" Carbonate,
" Sulphate,
" Acetate,
" Nitrate,
Zinc Carbonate,
" Sulphate,
" Chloride,
Nickel Carbonate,
" Sulphate,
" Chloride,
" Ammonium Sulphate,
Iron Sulphate,
" Chloride,
Sesquichloride of Iron,
Nitrate of Tin,
Tin Chloride, or Muriate of Tin,
Gold Chloride,
Silver "
Platinum "
Silver Nitrate,
Lead "
" Acetate,
Lye or Potash,
Kalye,
Calcium Chloride.

## APPARATUS AND CHEMICALS NECESSARY FOR THE METHODS OF ANALYSIS OF THE SOLUTIONS.

½ pound.....Potassium Iodide, C.P.cryst.U.S.P.
½ pound.....Potassium Sulphocyanate, C. P.
1 ounce.....Phenolphtaleine, Pure,
½ pound.....Acid Carbolic, C.P.
2 ounces....Silver Nitrate, C.P.
1 pound.....Sodium Hydroxide Electrolytic sticks,
1 ounce.....Nickel Metal Co. free Gran. C.P.
25 grams.....Copper Electrolytic Foil Kb. Reag.
½ pound.....Aluminum Metal Foil 5/1000 in., pure,
1 pound.....Hydrogen Peroxide Marchand,
½ pound.....Ammonium Molybdate C.P.
5 pounds....Iron Sulphide Broken Plates,
1 book.....100 Strips each Litmus Blue,
1 book.....100 Strips each Litmus Red,
4 pounds....Ammonium Hydrate 26 deg. Baker's anal. chem.
9 pounds....Acid Sulphuric, 1,
6 pounds....Acid Hydrochloric,
7 pounds....Acid Nitric,
1 .....Bunsen Burner,
4 feet.....Rubber Tubing, Black, $\frac{3}{16}$ inch diam. (4 ozs.)
3 feet.....Rubber Tubing, ¼ inch diam. (6 ozs.)
1 .....Tripod, Iron,
3 .....Beakers, Jena, Griffin's, 250 c.c.,
2 ..... ditto 400 c.c.,
2 ..... ditto 600 c.c.,
2 .....Flasks, Jena Erlenmeyer 500 c.c.,

1 .....Cylinder, Lipped, Graduated 100 c.c.
2 .....Burettes, Mohr's, 50 c.c. $\frac{1}{10}$ c.c. subdivisions,
1 ..... ditto 100 c.c. $\frac{1}{10}$ c.c. subdivisions,
1 .....Support for Burettes,
1 .....Flask, 250 c.c.
1 ..... " 1000 c.c.
Reagent Bottles White Labels and Black Letters:
1 .....Reagent Bottle 12 oz. "Acid Sulphuric Conc."
1 .....Reagent Bottle 12 oz. "Acid Sulphuric Dil."
1 .....Reagent Bottle 12 oz. "Acid Hydrochloric."
1 .....Reagent Bottle 12 oz. "Acid Nitric."
1 .....Reagent Bottle 12 oz. "Ammonium Hydrate."
2 .....Funnels, Glass, 3 inch diameter,
1 .....Nest of three Funnels, Glass,
6 .....Funnels Cylindrical, 2 ozs.,
1 .....Pipette 5 c.c.
1 ..... " 10 c.c.
1 ..... " 25 c.c.
1 .....Pipette 50 c.c.
1 ..... " 100 c.c.
1 .....Thermometer 400 deg. F.,
1 box.....Labels, No. 201,
1 box..... " 223,
1 .....Spatula, Blade 3 inches,
1 .....Gas Generator, Dudley's for $H_2S$
1 pound.....Glass Tubing, ¼ inch external diameter,

1 pound.....Glass stirring rods, assorted sizes,
1 .....File, Triangular, 4 inch,
1 .....Wash Bottle, 1 Pint,
1 .....Wash Bottle, 1 Quart,
1 .....Support for Funnels,
2 pkgs.....Filter Papers, E. & A. diameter 13 cm.,
3 .....Watch Glasses 3¼ inch diameter,
3 ..... " " 4 inch diameter,
½ dozen.....Test tubes 6 x ⅝ inch.,
1 .....Support for 13 Test Tubes,
1 .....Kjeldahl Connecting Bulbs Tube, small,
1 .....Condenser, Liebig end drawn out 15 inches,
2 .....Drying Tubes (Peligot Tubes) 6 inch.,
3 .....Rubber Stoppers, solid, No. 1, ..... 6 ozs.
3 .....Rubber Stoppers, solid, No. 3, ..... 6 ozs.
3 .....Rubber Stoppers, solid, No. 6, ..... 6 ozs.

## ANTIDOTES FOR POISONS USED IN PLATING ROOM.

Nitric, hydrochloric or sulphuric acids: Administer abundance of tepid water to act as an emetic, or swallow milk, the white of eggs, some lime, or a mixture of chalk and water.

If those acids in a concentrated state have been spilled on the hands or any part of the skin, apply a mixture of whiting and olive oil. If the quantity is very small, simple swilling with plenty of cold water will suffice.

**Useful Mixture:**

Mixture, if in cases of burning with strong sulphuric acid, is formed with 1 ounce of quick lime slacked with ¼ of an ounce of water, then adding to a quart of water. After standing 2 hours, pour off the clear liquid and mix it with olive oil to form thin paste.

**Potassium Cyanide, Hydrocyanide Acid, etc.:**

If cyanides, such as a drop of an ordinary plating solution, has been accidentally swallowed, water as cold as possible should be run on the head and spine of the sufferer, and a dilute solution of iron acetate, citrate, or tartrate administered.

If hydrocyanic acid vapors have been inhaled, cold water should be applied as above, and the patient be caused to inhale atmospheric air containing a little of chlorine gas.

It is a dangerous practice to dip the arms into a plating solution to recover any work

that has fallen off the wires, because the skin often absorbs cyanide liquids, causing painful sores, in such a case, wash well with water and apply with olive oil and lime water.

**Mixture, Alkalies:**

These bodies are the opposite to acids in character, so that acids may be used as antidotes. It is preferable to employ weak acids, such as vinegar or lemonade; but if these are not at hand, then use exceedingly dilute sulphuric or even nitric acid diluted, so that it just possesses a decidedly sour taste. After about 10 minutes take a few teaspoonfuls of olive oil.

**Mercury Salts:**

The white of an egg is the best antidote in this case.

Sulphur or sulphureted hydrogen are also serviceable for the purpose.

**Copper Salts:**

The stomach should be quickly emptied by means of emetic, or in want of this, the patient should thrust his finger to the back of his throat so as to tickle the uvala, and thus induce vomiting. After vomiting, drink milk, white of an egg, or gum water.

**Lead Salts:**

Proceed as in case of copper salts. Lemonade, soda water and sodium carbonate are also serviceable.

**Acid Vapors:**

Admit immediately an abundance of fresh air, and inhale the vapors of ammonia, or a few drops of ammonia may be put into a glass of water and the solution drank. Take plenty of hot drinks, and excite warmth by friction. Employ hot foot-baths to remove the flood from the lungs. Keep the throat moist by sipping milk.

**Removal of Stains, etc.:**

To remove stains of copper sulphate, or salts of mercury, gold, silver, etc., from the hands, wash them with a very dilute solution of ammonia, and with plenty of water; if the stains are old ones, they should be rubbed with the strongest acetic acid, and then treated as above.

**GREASE, OIL, TAR, ETC.**, may be easily removed from the hands or clothes by washing with a little Oakite or rubbing with a rag saturated with a solution of Oakite of 1 ounce per gallon.

## WEIGHTS AND MEASURES.

### Linear Measurements.

10 millimeters (mm.) = 1 centimeter (cm.)
10 centimeters = 1 decimeter (dm.)
10 decimeters = 1 meter (m.)
Equivalent, 1 inch = 2.5 cm. (approximately)

### Square Measurements.

100 sq. millimeters ($mm^2$) = 1 sq. centimeter ($cm^2$)
100 sq. centimeters = 1 sq. decimeter ($dm^2$)
100 sq. decimeters = 1 sq. meter ($m^2$)

### Cubic Measurements.

1000 cu. millimeters ($mm^3$) = 1 cu. centimeter (cc or $cm^3$)
1000 cu. centimeters = 1 cu. decimeter ($dm^3$)
1000 cu. decimeters = 1 cu. meter ($m^3$)
Equivalents, 1000 cc. = 1 liter (1 l.)
1 l. = 1 quart (approximately)

### Conversion Table.

1 cc. of water (S.T.P.) = 1 g.
1 l. of water (S.T.P.) = 1 k.
30 g. = 1 ounce (approximately)
1 k. = 2.2 pounds (approximately)
1 g. = 15 gr. (approximately)
1 l. hydrogen = .09 g. (approximately)

### Troy Weight.

| | | |
|---|---|---|
| 24 grains | = | 1 dwt. |
| 20 dwts. | = | 1 ounce. |
| 12 ounces | = | 1 pound. |

Used for weighing gold, silver and jewels.

### Apothecaries' Weight.

| | | |
|---|---|---|
| 20 grains | = | 1 scruple. |
| 3 scruples | = | 1 dram. |
| 8 drams | = | 1 ounce. |
| 12 ounces | = | 1 pound. |

The ounce and pound in this are the same as in Troy weight.

### Avoirdupois Weight.

| | | |
|---|---|---|
| 27 11-32 grains | = | 1 dram. |
| 16 drams | = | 1 ounce. |
| 16 ounces | = | 1 pound. |
| 25 pounds | = | 1 quarter. |
| 4 quarters | = | 1 cwt. |
| 2,000 pounds | = | 1 short ton. |
| 2,240 pounds | = | 1 long ton. |

### Dry Measure.

| | | |
|---|---|---|
| 2 pints | = | 1 quart. |
| 8 quarts | = | 1 peck. |
| 4 pecks | = | 1 bushel. |
| 36 bushels | = | 1 chaldron. |

### Liquid Measure.

| | | |
|---|---|---|
| 4 gills | = | 1 pint. |
| 2 pints | = | 1 quart. |
| 31½ gallons | = | 1 barrel. |
| 2 barrels | = | 1 hogshead. |

### Time Measure.

| | | |
|---|---|---|
| 60 seconds | = | 1 minute. |
| 60 minutes | = | 1 hour. |
| 24 hours | = | 1 day. |
| 7 days | = | 1 week. |
| 28, 29, 30 or 31 days | = | 1 calendar month (30 ds.) |
| 365 days | = | 1 year. |

### Circular Measure.

| | | |
|---|---|---|
| 60 seconds | = | 1 minute. |
| 60 minutes | = | 1 degree. |
| 30 degrees | = | 1 sign. |
| 90 degrees | = | 1 quadrant. |
| 4 quadrants | = | 12 signs. |
| 360 degrees | | 1 circle. |

### Long Measure.

| | | |
|---|---|---|
| 12 inches | = | 1 foot. |
| 3 feet | = | 1 yard. |
| 5½ yards | = | 1 rod. |
| 40 rods | = | 1 furlong. |
| 8 furlongs | = | 1 statute mile. |
| 3 miles | = | 1 league. |

### Weight Table.

| | | |
|---|---|---|
| 10 milligrams (mg.) | = | 1 centigram (cg.) |
| 10 centigrams | = | 1 decigram (dg.) |
| 10 decigrams | = | 1 gram (g.) |
| 1000 grams | = | 1 kilogram (k.) |

### Square Measure.

| | | | |
|---|---|---|---|
| 144 | sq. inches | = | 1 sq. foot. |
| 9 | sq. feet | = | 1 sq. yard. |
| 30¼ | sq. yards | = | 1 sq. rod. |
| 40 | sq. rods | = | 1 rood. |
| 4 | roods | = | 1 acre. |
| 640 | acres | = | 1 sq. mile. |

### Cubic Measure.

| | | | |
|---|---|---|---|
| 1,728 | cubic inches | = | 1 cubic foot. |
| 27 | cubic feet | = | 1 cubic yard. |
| 128 | cubic feet | = | 1 cord (wood). |
| 40 | cubic feet | = | 1 ton (shpg.) |

2,150.42 cubic inches = 1 standard bushel.
268.8 cubic inches = 1 standard gallon.
1 cubic foot = about four-fifths of a bushel.

### Approximate Metric Equivalents.

| | | | |
|---|---|---|---|
| 1 decimeter | = | 4 | inches. |
| 1 meter | = | 1.1 | yards. |
| 1 kilometer | = | ⅝ | of mile. |
| 1 hektar | = | 2 ½ | acres. |
| 1 stere or cu. meter | = | ¼ | of a cord. |
| 1 liter | = | 1.06 | qt. liquid. |
| 1 liter | = | 0.9 | qt. dry. |
| 1 hektoliter | = | 2 ⅝ | bush. |
| 1 kilogram | = | 2 1/5 | lbs. |
| 1 metric ton | = | 2,200 | lbs. |

## Measure of Volume.

| | | | |
|---|---|---|---|
| 1 cu. centimeter | = | 0.061 | cu. in. |
| 1 cu. decimeter | = | 0.0353 | cu. ft. |
| 1 cu. meter | = | 1.308 | cu. yd. |
| 1 stere | = | 0.2759 | cd. |
| 1 liter | = | 0.908 | qt. dry. |
| 1 liter | = | 1.0567 | qt. liq. |
| 1 dekaliter | = | 2.6417 | gal. |
| 1 dekaliter | = | .135 | pks. |
| 1 hektoliter | = | 2.8375 | bush. |
| 1 cu. inch | = | 16.39 | cu. cent'rs. |
| 1 cu. foot | = | 28.317 | cu. deci'rs. |
| 1 cu. yard | = | 0.7646 | cu. M'r. |
| 1 cord | = | 3.624 | steres. |
| 1 quart dry | = | 1.101 | liters. |
| 1 quart liquid | = | 0.9463 | liter. |
| 1 gallon | = | 0.3785 | dekaliter. |
| 1 peck | = | 0.881 | dekaliter. |
| 1 bushel | = | 0.3524 | hektoliter. |

## METRIC EQUIVALENTS.

### Linear Measure.

| | | |
|---|---|---|
| 1 centimeter | = 0.3937 | inches. |
| 1 decimeter | = 3.937 | in.=0.328 ft. |
| 1 meter | = 39.37 | in.=1.0936 yds. |
| 1 dekameter | = 1.9884 | rods. |
| 1 kilometer | = 0.62137 | mile. |
| 1 inch | = 2.54 | centimeters. |
| 1 foot | = 3.048 | decimeters. |
| 1 yard | = 0.9144 | meter. |
| 1 rod | = 0.5029 | dekameter. |
| 1 mile | = 1.6093 | kilometers. |

### Square Measure.

| | | |
|---|---|---|
| 1 sq. centimeter | = 0.1550 | sq. inches. |
| 1 sq. decimeter | = 0.1076 | sq. feet. |
| 1 sq. meter | = 1.196 | sq. yards. |
| 1 ar | = 3.954 | sq. rd. |
| 1 hektar | = 2.47 | acres. |
| 1 sq. kilometer | = 0.386 | sq. m. |
| 1 sq. inch | = 6.452 | sq. centimeters. |
| 1 sq. foot | = 9.2903 | sq. decimeters. |
| 1 sq. yard | = 0.8361 | sq. meter |
| 1 sq. rod | = 0.8361 | sq. ar. |
| 1 acre | = 0.4047 | hektar. |
| 1 sq. mile | = 2.59 | sq. kilometers. |

### Weights.

| | | |
|---|---|---|
| 1 gram | = 0.03527 | ounce. |
| 1 kilogram | = 2.2046 | lbs. |
| 1 metric ton | = 1.1023 | English ton. |
| 1 ounce | = 28.85 | grams. |
| 1 pound | = 0.4536 | kilogram. |
| 1 English ton | = 0.9072 | metric ton. |

## CAPACITIES OF RECTANGULAR TANKS IN U. S. GALLONS FOR EACH FOOT IN DEPTH

### For Ordinary Requirements Use O. P. C. ½ lb. per Gallon.

LENGTH OF TANK

| Width of Tank | 7′ 6″ | 8′ | 8′ 6″ | 9′ | 9′ 6″ | 10′ | 10′ 6″ | 11′ | 11′ 6″ | 12′ |
|---|---|---|---|---|---|---|---|---|---|---|
| 2′ | 112.21 | 119.69 | 127.17 | 134.65 | 142.13 | 149.61 | 157.09 | 164.57 | 172.05 | 179.53 |
| 2′ 6″ | 140.26 | 149.61 | 158.96 | 168.31 | 177.66 | 187.01 | 196.36 | 205.71 | 215.06 | 224.41 |
| 3′ | 168.31 | 179.53 | 190.75 | 202.97 | 213.19 | 224.41 | 235.63 | 246.86 | 258.07 | 269.30 |
| 3′ 6″ | 196.36 | 209.45 | 222.54 | 235.63 | 248.73 | 261.82 | 274.90 | 288.00 | 301.09 | 314.18 |
| 4′ | 224.41 | 239.37 | 254.34 | 269.30 | 284.26 | 299.22 | 314.18 | 329.14 | 344.10 | 359.06 |
| 4′ 6″ | 252.47 | 269.30 | 286.13 | 302.96 | 319.79 | 336.62 | 353.45 | 370.28 | 387.11 | 403.94 |
| 5′ | 280.52 | 299.22 | 317.92 | 336.62 | 355.32 | 374.03 | 392.72 | 411.43 | 430.13 | 448.83 |
| 5′ 6″ | 308.57 | 329.14 | 349.71 | 370.28 | 390.85 | 411.43 | 432.00 | 452.57 | 473.14 | 493.71 |
| 6′ | 336.62 | 359.06 | 381.50 | 403.94 | 426.39 | 448.83 | 471.27 | 493.71 | 516.15 | 538.59 |
| 6′ 6″ | 364.67 | 388.98 | 413.30 | 437.60 | 461.92 | 486.23 | 510.54 | 534.85 | 559.16 | 583.47 |
| 7′ | 392.72 | 418.91 | 445.09 | 471.27 | 497.45 | 523.64 | 549.81 | 575.99 | 602.18 | 628.36 |
| 7′ 6″ | 420.78 | 448.83 | 476.88 | 504.93 | 532.98 | 561.04 | 589.08 | 617.14 | 645.19 | 673.24 |
| 8′ | ..... | 478.75 | 508.67 | 538.59 | 568.51 | 598.44 | 628.36 | 658.28 | 688.20 | 718.12 |
| 8′ 6″ | ..... | ..... | 540.46 | 572.25 | 604.05 | 635.84 | 667.42 | 699.42 | 731.21 | 763.00 |
| 9′ | ..... | ..... | ..... | 605.92 | 639.58 | 673.25 | 706.90 | 740.56 | 774.23 | 807.89 |
| 9′ 6″ | ..... | ..... | ..... | ..... | 675.11 | 710.65 | 746.17 | 781.71 | 817.24 | 852.77 |
| 10′ | ..... | ..... | ..... | ..... | ..... | 748.05 | 785.45 | 822.86 | 860.26 | 897.66 |

1 Cubic Foot Equals 7.4805 U. S. Gallons.
1 U. S. Gallon = 231 Cubic In.

# CAPACITIES OF RECTANGULAR TANKS IN U. S. GALLONS FOR EACH FOOT IN DEPTH

## For Ordinary Requirements Use O. P. C. ½ lb. per Gallon.

LENGTH OF TANK

| Width of Tank | 2′ | 2′ 6″ | 3′ | 3′ 6″ | 4′ | 4′ 6″ | 5′ | 5′ 6″ | 6′ | 6′ 6″ | 7′ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2′ | 29.92 | 37.40 | 44.88 | 52.36 | 59.84 | 67.32 | 74.81 | 82.29 | 89.77 | 97.25 | 104.73 |
| 2′ 6″ | ..... | 46.75 | 56.10 | 65.45 | 74.80 | 84.16 | 93.51 | 102.86 | 112.21 | 121.56 | 130.91 |
| 3′ | ..... | ..... | 67.32 | 78.54 | 89.77 | 100.99 | 112.21 | 123.43 | 134.65 | 145.87 | 157.09 |
| 3′ 6″ | ..... | ..... | ..... | 91.64 | 104.73 | 117.82 | 130.91 | 144.00 | 157.09 | 170.18 | 183.27 |
| 4′ | ..... | ..... | ..... | ..... | 119.69 | 134.65 | 149.61 | 164.57 | 179.53 | 194.49 | 209.45 |
| 4′ 6″ | ..... | ..... | ..... | ..... | ..... | 151.48 | 168.31 | 185.14 | 201.97 | 218.80 | 235.63 |
| 5′ | ..... | ..... | ..... | ..... | ..... | ..... | 187.01 | 205.71 | 224.41 | 243.11 | 261.82 |
| 5′ 6″ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 226.28 | 246.86 | 267.43 | 288.00 |
| 6′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 269.30 | 291.74 | 314.18 |
| 6′ 6″ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 316.05 | 340.36 |
| 7′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 366.55 |

1 Cubic Foot Equals 7.4805 U. S. Gallons.

1 U. S. Gallon = 231 Cubic In.

# CYLINDRICAL VESSELS, TANKS, CISTERNS, ETC.

**For Ordinary Requirements Use O. P. C. ½ Lb. Per Gallon**

## Diameter in Feet and Inches, Area in Square Feet and U. S. Gallons Capacity for One Foot in Depth.

| DIAMETER | | Area Square | Gallons One Foot | DIAMETER | | Area Square | Gallons One Foot |
|---|---|---|---|---|---|---|---|
| Feet | Inches | Feet | Depth | Feet | Inches | Feet | Depth |
| 1 | ..... | .785 | 5.87 | 4 | 6 | 15.90 | 118.97 |
| 1 | 1 | .922 | 6.89 | 4 | 7 | 16.50 | 123.42 |
| 1 | 2 | 1.069 | 8.00 | 4 | 8 | 17.10 | 127.95 |
| 1 | 3 | 1.227 | 9.18 | 4 | 9 | 17.72 | 132.56 |
| 1 | 4 | 1.396 | 10.44 | 4 | 10 | 18.35 | 137.25 |
| 1 | 5 | 1.576 | 11.79 | 4 | 11 | 18.99 | 142.02 |
| 1 | 6 | 1.767 | 13.22 | | | | |
| 1 | 7 | 1.969 | 14.73 | 5 | ..... | 19.63 | 146.88 |
| 1 | 8 | 2.182 | 16.32 | 5 | 1 | 20.29 | 151.82 |
| 1 | 9 | 2.405 | 17.99 | 5 | 2 | 20.97 | 156.83 |
| 1 | 10 | 2.640 | 19.75 | 5 | 3 | 21.65 | 161.93 |
| 1 | 11 | 2.885 | 21.58 | 5 | 4 | 22.34 | 167.12 |
| | | | | 5 | 5 | 23.04 | 172.38 |
| 2 | ..... | 3.142 | 23.50 | 5 | 6 | 23.76 | 177.72 |
| 2 | 1 | 3.409 | 25.50 | 5 | 7 | 24.48 | 183.15 |
| 2 | 2 | 3.687 | 27.58 | 5 | 8 | 25.22 | 188.66 |
| 2 | 3 | 3.976 | 29.74 | 5 | 9 | 25.97 | 194.25 |
| 2 | 4 | 4.276 | 31.99 | 5 | 10 | 26.73 | 199.92 |
| 2 | 5 | 4.587 | 34.31 | 5 | 11 | 27.49 | 205.67 |
| 2 | 6 | 4.909 | 36.72 | | | | |
| 2 | 7 | 5.241 | 39.21 | | | | |
| 2 | 8 | 5.585 | 41.78 | 6 | ..... | 28.27 | 211.51 |
| 2 | 9 | 5.940 | 44.43 | 6 | 3 | 30.68 | 229.50 |
| 2 | 10 | 6.305 | 47.16 | 6 | 6 | 33.18 | 248.23 |
| 2 | 11 | 6.681 | 49.98 | 6 | 9 | 35.78 | 267.69 |
| 3 | ..... | 7.069 | 52.88 | 7 | ..... | 38.48 | 287.88 |
| 3 | 1 | 7.467 | 55.86 | 7 | 3 | 41.28 | 308.81 |
| 3 | 2 | 7.876 | 58.92 | 7 | 6 | 44.18 | 330.48 |
| 3 | 3 | 8.296 | 62.06 | 7 | 9 | 47.17 | 352.88 |
| 3 | 4 | 8.727 | 65.28 | | | | |
| 3 | 5 | 9.168 | 68.58 | 8 | ..... | 50.27 | 376.01 |
| 3 | 6 | 9.621 | 71.97 | 8 | 3 | 53.46 | 399.88 |
| 3 | 7 | 10.085 | 75.44 | 8 | 6 | 56.75 | 424.48 |
| 3 | 8 | 10.559 | 78.99 | 8 | 9 | 60.13 | 449.82 |
| 3 | 9 | 11.045 | 82.62 | | | | |
| 3 | 10 | 11.541 | 86.33 | 9 | ..... | 63.62 | 475.89 |
| 3 | 11 | 12.048 | 90.13 | 9 | 3 | 67.20 | 502.70 |
| | | | | 9 | 6 | 70.88 | 530.24 |
| 4 | ..... | 12.566 | 94.00 | 9 | 9 | 74.66 | 558.51 |
| 4 | 1 | 13.095 | 97.96 | | | | |
| 4 | 2 | 13.635 | 102.00 | 10 | ..... | 78.54 | 587.52 |
| 4 | 3 | 14.186 | 106.12 | 10 | 3 | 82.52 | 617.26 |
| 4 | 4 | 14.748 | 110.32 | 10 | 6 | 86.59 | 647.74 |
| 4 | 5 | 15.321 | 114.61 | 10 | 9 | 90.76 | 678.95 |

1 gallon equals 231 cubic inches, equals $\frac{\text{1 cubic foot}}{7.4805}$ equals 0.13368 cubic feet.

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